Science Education

The Science Magazine for All Science Teachers

Formerly General Science Quarterly

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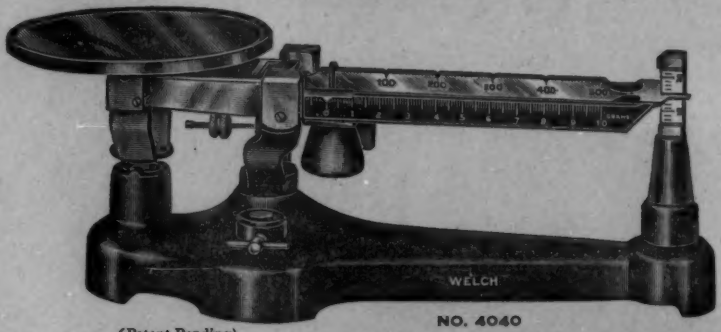

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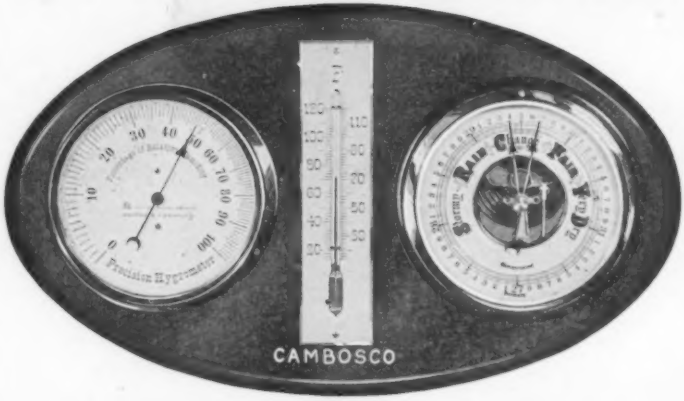

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WHAT IS SCIENCE?

Science is nothing but trained and organized common sense.—*Huxley.*

Science is nothing more or less than the most accurate and best authenticated information that exists, subject to constant rectification and amplification, of man and his world.—*Robinson.*

The scientist is a questioner, a discoverer, a pointer-out.—*Robinson.*

Science is an orderly or systematic arrangement of statements of fact or truth; that is scientific in which all the statements are accurate and their correct relation to each is set forth in logical order. —*Crane.*

Science embraces the whole immense round of truth. —*Crane.*

Science is an intellectual outlook, a standard of truth and a gospel of light.—*Gregory.*

The first object of a course in science should be to develop a scientific habit of thought.—*Remsen.*

The object of science is to codify knowledge and to describe relations between phenomena in the simplest possible terms.—*East.*

Science is thoughtful inquiry into the order of nature, human nature included.—*Curtis.*

Science is the product of human reason applied to the phenomena of nature. The straight thinking man was always a scientist.—*Curtis.*

Scientists are not wizards, but men who apply to natural phenomena the methods of analysis used by logical minds in the affairs of daily life.—*Curtis.*

Science, in short, includes all the careful and critical knowledge we have about anything of which we can come to know something.—*Robinson.*

SCIENCE EDUCATION

Devoted to the Teaching of Science in Elementary Schools, Junior and Senior High Schools, Colleges and Teacher Training Institutions

(Formerly GENERAL SCIENCE QUARTERLY)

Vol. XIV NOVEMBER, 1929 No. 1

Editorial Comments

Science Education Enlarges Its Editorial Staff

The enlarged scope and new plan of publication of *Science Education* was announced in the May issue of the journal. As the present issue goes to press the editorial board has another important announcement to make to its readers.

It is the policy of *Science Education* to devote its pages to the improvement of the teaching of science at all levels from the kindergarten to the senior college. Readers will find in the present and forthcoming numbers one or more articles relating to each of the several major fields of science education. The fields to be represented are: (1) Nature Education and Elementary Science, (2) Junior High School Science or "General Science," (3) Senior High School Biology, (4) Senior High School Physics, (5) Senior High School Chemistry, (6) Training of Science Teachers, (7) Supervision of Science Instruction, and (8) Research in Science Education. Beginning with the January issue the book review section will be enlarged and there will appear an abstract section in which will be found abstracts of articles appearing in other educational periodicals as well as abstracts of investigations completed in various sections of the country.

To carry forward this enlarged plan, the editorial board has been increased by the selection of a number of associate editors, divided into three groups: editors of articles, editors of book reviews, and editors of abstracts. The list of associate editors is practically complete at the present time and includes the names of outstanding leaders in the field of science education. We are pleased to announce the names of those who have enthusiastically responded to our request and have offered their services for the improvement of the journal.

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Readers who may desire to submit articles or abstracts of studies or investigations for publication in the journal are requested to forward them directly to the appropriate editor or to the chairman of the editorial board. Directions and suggestions concerning the form of submitted articles and abstracts may be had upon request from the editors.

COMMUNICATIONS

Science Education invites its readers to send to the editor any comments on or critical discussions of articles appearing in its pages, and also to offer suggestions concerning the content and policy of the journal. Such communications will be published. If the returns warrant it, a special section of the magazine will be set aside for communications.

MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

The annual meeting of Central Association of Science and Mathematics Teachers will be held at the University of Chicago on November 29th and 30th. An advance notice of this meeting promises a program of addresses by recognized leaders in the field of science education. The annual dinner will be given on Friday evening, November 29th.

MEETING OF AMERICAN NATURE STUDY SOCIETY

The thirty-third annual meeting of the American Nature Study Society will be held at Des Moines, Iowa, on December 27th and 28th in connection with the meeting of the American Association for the Advancement of Science. The program will center on these themes:

(a) The redefinition of the nature study idea.
(b) Articulation of nature study activities.
(c) Experimental and research work in nature education.

The list of speakers includes several of the early leaders in the field of nature education as well as a number of those who are now engaged in outstanding activities in the field. The annual dinner on Saturday evening, December 28th, will have as its honor guests the past presidents of the society. Reservations for the dinner may be sent to Miss Lillian Hethershaw, Drake University, Des Moines, Iowa.

Techniques for the Determination of Basic Principles in Science Courses

E. R. Downing, University of Chicago

The knowledge of science which students acquire in the course of their education is of value in solving the problematic situations of life in proportion as it is in the form of principles sufficiently well-mastered to be readily applicable. To accomplish such mastery students must have much drill in solving concrete problems. A thesis by Benjamin C. Shafer, (1923), University of Chicago, The School of Education, shows that there is little correlation between a student's ability to state a principle of physics and his ability to apply it to problems that arise unless he has been forced repeatedly to so apply it.

If it be true that our scientific knowledge is serviceable only when it is in the form of well-mastered principles, then it is imperative that we undertake to find out what principles of science are most needed in solving the problems most frequently encountered in life and at what grade levels they can be most effectively taught. Evidently those of maximum importance should be mastered as early in the schools as possible, else many pupils will go out into life inadequately equipped in scientific knowledge, to face problems that will inevitably rise.

The alternative to this plan is to discover those problematic situations most likely to arise and teach pupils how to meet each one by rule of thumb, not by an understanding of the principles involved. That is precluded by the multiplicity of specific things to be taught. Moreover one cannot be certain just what problems will arise in the life of a given pupil but he can be reasonably sure that most of them will involve the application of a relatively few principles.

In the determination of the principles of science of most importance in life at least three methods of attack have been followed:

1. An analysis of text books in science in terms of principles and their applications to see what principles are deemed of largest importance by those experts who have written texts in the various science subjects.

2. An analysis of current periodicals, newspapers, widely-read journals like the Literary Digest, trade journals, such as those of the farmer, mechanic, etc., to find what principles of science are needed to read such intelligently and to what concrete problematic situations these principles are applied.

3. To follow about for weeks persons in various occupations — the farmer, housewife, etc. — and list the problematic situations that arise and the principles upon which their successful solution depends.

A number of investigations have been completed, others are in progress along these lines at the School of Education, The University of Chicago. Luther L. Ambrose ('28) analyzed the issues of the Literary Digest covering a ten-year period. Mr. Hedebol ('24) analyzed a number of secondary textbooks in Botany; Mr. Monto ('25) similar texts in Zoology; Mr. Hackett ('24) in Biology; Mrs. Heineman ('27) in General Science (Nov. 1928, *G. S. Quarterly*); Miss Menzies ('27) analyzed ten college texts books in biology; Miss Nuser ('26) analyzed several years' issues of a number of the most widely circulated farm journals to see what principles of chemistry the farmer needed and what practical application of these he encountered. Mr. Watson and Mr. Widner (both 1928) have made similar studies on the physics materials of such farm journals. Mr. Harris ('27) has analyzed a number of trade journals to determine the same. Miss Coon ('27) an expert in domestic science, has reviewed the activities of the housewife to find what principles of science she needs and to what problematic situations these apply. This last was an independent investigation published by the Government. (Federal Board of Vocational Education, Misc. 837, Rev.)

It will evidently be impossible in the space of a short paper to even briefly review all of these. I must be content to comment on the value of the methods and present some summary of the findings in physics.

The analysis of text books will prove, I fear, of little value in determining what principles of science are of largest value in life situations. Such texts aim apparently to cover the field rather than select for treatment the important principles. They largely neglect all applications. For instance, Hackett's analysis of biology texts shows that from ¼ to less than ½ of such texts deal with principles. The percentage is greater

in college texts. Miss Menzies finds from 87.6% to 96.6% of the word space in ten college texts in biology is devoted to principles and applications. One hundred and thirty-six principles are treated in these texts, the average number of applications under any and all these principles is 8. Only five of the generalizations are treated by all ten authors, one by nine, four by eight, ten by six, five by five—i.e. only twenty-five out of one hundred and thirty-six are touched by half or more of the authors, while sixty-one are treated by only a single author. There is little consensus as to what principles are important and there is little tendency to apply them to concrete problematic situations.

Miss Coon lists twenty-three principles, only nine of which are found in other lists. Harris lists fifty-six, twenty-five of which are not found in other lists; Watson lists forty-seven, only five of which are not in other lists and Widner lists forty-six, nineteen of which are not found in other lists. There is given below a list of all those principles found in any two or more of these investigations — thirty-two all told. In each case there is given the index number of its importance in each of the four investigations, number 1 indicating the maximum importance. The importance is determined in terms of the amount of word space devoted to discussion of this particular principle or its applications to concrete situations.

The principles that stand out as conspicuously important are relatively few. Thus the first twenty of Widner's list include 76.59 per cent of the total word space devoted to physics, 73 per cent of the total number of articles, and 66.9 per cent of the 332 applications.

Here at least is some fact basis for selecting those principles of physics to be taught in the grades and the junior high school if possible. Of course more investigations are needed before an adequate basis for selection is achieved but the facts given are better than none and probably we may proceed upon these results until further investigations show need of modification. This paper, however, has been presented not primarily for the value of the facts but as a contribution to the technique of the selection of curriculum material.

A brief summary of the principles of physics and their order of importance, as determined by several investigators, is here given:

PRINCIPLES OF PHYSICS

The numbers on the right-hand side of the paper indicate the order of importance of these principles as reported by Coon, Harris, Watson and Widner. Importance is estimated on basis of word space devoted to each (except Coon).

	C.	H.	Wa.	Wi.
1. A body is stable when its center of gravity is over its base.	5	..	..	43
2. Equilibrium: When the resultant of all the forces acting upon a body are zero no change of motion of the body is produced.	..	37	36	..
3. Parallel Forces: The resultant of forces acting in opposite directions along the same line is a force equal to their difference, acting along the same line in the direction of the greater.	..	45	26	2
4. Atmospheric Pressure: The gases of the atmosphere (the air) have weight and exert a pressure of 14.7 lbs. per square inch at sea level. This pressure is transmitted in all directions and is proportional to the height of the column of air.	..	10	4	8
5. Boyle's Law: The temperature remaining the same, the volume of a given body of gas varies inversely as the pressure upon it.	..	14	12	17
6. Pascal's Law: The pressure applied to any part of an inclosed fluid is transmitted undiminished throughout the fluid, with unchanged intensity, to all parts of the interior surface of the vessel, and its direction is everywhere perpendicular to the surface.	8	31	47	5
7. Gravity pressure: The pressure at any point in a liquid at rest is directly proportional to the density of the liquid and to the depth of the point below the free surface of the liquid, and at any point the pressure is the same in all directions.	..	7	9	..
8. Archimedes' Principle: A body either wholly or partially immersed in a liquid is buoyed up by a force equal to the weight of the liquid displaced by it.	..	3	40	36
9. Lever: "The moment of the effort applied to a rigid bar capable of moving about a fixed point is equal to the moment of the resistance."	..	..	6	11
10. The Pulley: The force applied to a pulley system times the distance through which it moves is equal to the product of the resistance times the distance through which it moves, and the ratio of the force applied to the resistance is proportional to the number of ropes pulling on the movable pulley.	..	..	29	19
11. The Inclined Plane: By means of an inclined plane a weight can be lifted by a force that has the same ratio to it as the length of the plane has to the height of the plane.	..	..	41	44

	C.	H.	Wa.	Wi.
12. Friction: When two moving bodies come in contact they produce a resisting force which in sliding motion is proportional to the pressure and independent of the extent of the surfaces in contact. Rolling friction depends upon the hardness and smoothness of the surfaces in contact.	..	8	7	41
13. Hooke's Law: Whenever the forces that produce distortion in a body are within the elastic limit, the distortion produced is directly proportional to the force that produces it.	..	9	32	32
14. Capillarity: If a solid be immersed in a liquid which wets it, the liquid will rise about the sides of the solid; if the liquid does not wet the solid, it is depressed about the solid.	3	26	43	20
15. Osmosis: A kind of unequal diffusion takes place between two miscible fluids separated by a porous septa. Rate varies with concentration.	7	56	..	..
16. Inertia: Every body continues in its state of rest or uniform motion in a straight line, except in so far as it is compelled to change that state by a force impressed upon it.	..	5	19	30
17. Work is the accomplishment of results, being the product of the mass and the distance moved.	..	4	..	9
18. Magnetism: Like magnetic poles repel and unlike poles attract each other. The force of attraction or repulsion varies directly as the magnetic strength of the poles and inversely as the square of the distance between them.	..	18	39	..
19. Ohm's Law: The electric current varies directly as the electromotive force and inversely as the resistance.	..	28	21	15
20. Electrical Heating: The heat developed by a current in a circuit is proportional to the square of the current, to the resistance of the circuit, and to the time which the current passes.	10	33	42	10
21. Induced Current: A current of electricity may be induced in a conductor by causing the latter to move through a magnetic field.	..	17	23	..
22. Transference of Heat: Heat may be transferred by convection currents, conduction, and radiation..	3	12	44	..
23. Change of State: Metals may be liquified and liquids vaporized by the application of heat, and vice versa.	..	19	3	..
24. Gases and most liquids and solids expand on heating and contract on cooling.	..	32	17	..
25. The heat required to change a substance from one form to another is equal to the heat given off when the process is reversed.	6	20	..	..
26. Bodies expand on heating in proportion to the rise in temperature.	5	..	..	37
27. Light manifests itself in the form of ether wave vibrations which travel in straight lines.	..	36	30	..
28. Reflection: Angle of incidence equals the angle of reflection.	6	11	38	23

	C.	H.	Wa.	Wi.
29. Refraction: When a light ray passes at an oblique angle from one medium to a more dense medium, it is bent toward the perpendicular; conversely when a light ray passes obliquely from a medium to a less dense medium, it is bent away from the perpendicular.	..	29	34	29
30. Illumination: Intensity of illumination varies inversely as the square of the distance from the source of illumination.	..	21	45	24
31. Frequency of vibrating string varies inversely as its length, radius, and square root of its density, and directly as the square root of its stretching force.	..	46	..	35
32. Heat is conducted in different degrees by various substances. Rate depends on difference in temperature of source and conductor.	1	..	16	..

The Freezing Point of Sulphuric Acid and Strength of Solution

The freezing point of sulphuric acid presents a very interesting study, although the information given here is by no means new. The oil of vitriol of commerce is known as 66° acid, that is, it tests 66° Baumé—the equivalent of 1,835 in specific gravity. At this strength it freezes at minus 29° F. (— 29° F.)

Sulphuric acid is extremely hygroscopic, absorbing moisture from the atmosphere with great rapidity. At first a very slight quantity of moisture will raise the freezing point very rapidly until at 60° Baumé the freezing point will be as high as + 12° F. Further accumulation of moisture depresses the freezing point to minus 59° F. (— 59° F.) when the acid tests 54° Baumé. A further increase in moisture serves to again raise the freezing point to minus 14° F. (— 14° F.) when acid tests 46° Baumé. At this point sulphuric acid practically ceases to be hygroscopic.

When the moisture content is increased to the point where the Baumé reading is 33° Baumé, the freezing point is found to be minus 97° F. (— 97° F.) From this point the addition of water raises the freezing point rapidly at first and more slowly toward the end, until the point is reached where the acid content is theoretically zero, when the freezing point is, of course, + 32° F., the freezing point of water.

The Activities of Science Teachers

HARRY A. CUNNINGHAM
Kent State College, Kent, Ohio

In the construction of a curriculum for science teachers, our first task is to recognize and define the problems that are peculiar to the teaching of science. So far, in our research work, we have been taking a problem here and a problem there without having before us a list of the actual teaching problems of the science teacher. We need not only to recognize and define the problems in the teaching of science, but we need to know the sequence in which it would be better to have them solved. There are various methods employed by research workers in the solution of various types of problems. We must not be slaves to a method in either our science teaching or in our research work. We must rather get a systematic picture of the field in mind and be able to see where all of the various methods of research, which are available, may be used to the best advantage.

The first step in recognizing and defining our teaching problems can probably best be taken by making a functional analysis of the teacher's job. By such a study the attempt is made to determine what the teacher actually does under present conditions. The necessary basis for further study in our special field has been well laid by "The Commonwealth Teacher Training Study" conducted by W. W. Charters and Douglas Waples.[1] This study has extended over a period of three years. A large three-story apartment building has been occupied almost entirely by the staff engaged in the enterprise. The staff was unusually complete with both technical and clerical assistants. A grant was provided by the Commonwealth fund for carrying on the work. This study has given us "a master list of the activities of teachers in the public schools from the primary grades through the senior high school." It has compared the activities of various types of teachers; and has evaluated the activities as to frequency, difficulty, importance, and desirability of teaching them in the teacher-training school. A composite rating on the basis

1 Charters, W. W. and Waples, Douglas—"The Commonwealth Teacher Training Study." The University of Chicago Press, Chicago, Ill.

of the other four ratings is also provided for each of the type activities. These activities were thus rated by teachers of science in the senior high school. The data from these ratings are highly important as a starting point for further research in the special field of science education. The following is a sample of the type of data that are found in Table E of the "Commonwealth Teacher Training Study."[2]

		F	D	I	S	C
24 C.	Selecting and organizing subject-matter.					
25.	Securing adequate command of subject-matter to be taught	1	10	1	1	1
26.	Taing account of specific objectives.....	1	1	2	4	1
27.	Taking account of pupils' interests, abilities and needs:					
28.	Selecting subject-matter with reference to pupils" interests	1	6	1	5	2
29.	Selecting subject-matter with reference to pupils' activities	2	4	2	3	2
30.	Selecting subject-matter with reference to pupils' needs	3	1	1	3	1

The letters F. D. I. S. and C stand respectively for frequency, difficulty, importance, desirability of pre-service training, and composite rating based upon the other four ratings. The figures in the columns represent the decile rank of each activity for each criteria.

The type activities provided in the "Commonwealth Study" are necessarily general enough to apply to all fields of subject matter. It becomes the problem, then, of the specialist in science education to further analyze the type activities of the "Commonwealth Study" into the more specific activities performed exclusively by science teachers. I shall now summarize briefly the activities which I have been trying to carry forward.

One problem has been to collect as large a list as possible of activities that are performed by science teachers and which are peculiar to science teaching. I have collected activities from the following sources: (1) twenty-three diaries were kept for me by high school biology teachers for a period of two weeks during the autumn of 1926; (2) I kept a diary of my activities in teaching high school chemistry and high school biology during the school year of 1926-27; (3) ten diaries were kept by biology teachers during the spring of 1927 for a period of two days only; (4) lists of teaching difficulties were obtained in the spring of 1927 from nine of the teachers who made diaries for me in the fall; (5) eight issues of

2 Charters, W. W. and Waples, Douglas—"Commonwealth Teacher Training Study," The University of Chicago Press, pp. 621-646.

School Science and Mathematics were studied and the activities mentioned in the articles on the teaching of science were listed. This did not prove to be a very fruitful source for obtaining teacher activities so the study of such articles was discontinued; (6) forty-two summer school students taking courses in the teaching of science during the summer quarter, 1926, at the University of Chicago, also made lists of activities that they had performed in the teaching of science; (7) there have been added to the list the activities listed on a questionnaire which was prepared by J. Aaron Smith at the University of Illinois and used by him in the preparation of a master's thesis dealing with the activities of chemistry and physics teachers. Other general lists of teacher activities have been studied but such study has been, on the whole, unfruitful, because of the general nature of the activities and difficulties. From these various sources I now have approximately 3300 separate and distinct activities that seem to be peculiar to science teaching.

Various methods of classification have been tried. The cards — each three-by-five card having on it one activity — have been classified according to first nouns. They have been classified also according to verbs. One may become familiar with the many technical problems in connection with classification by referring to the "Commonwealth Teacher Training Study." For the purpose of carrying forward the further analysis of the "Commonwealth Study" into the more specific activities performed exclusively by science teachers, the cards are now fitted into the classification of that study. Where possible the type activities are being broken up into the more specific activities which are peculiar to our special field. Such type activities, from the "Commonwealth Study," as the following lend themselves admirably to further analysis in our study: (1) "Obtaining information from sources other than reading; (2) Collecting necessary supplies and equipment; (3) Improving skills and abilities." The classification of the activities under the type activities of the "Commonwealth Study" is made objective by the formulation of rules that will cover every case. In the following paragraph we shall note some items of interest that have come up as the study progressed.

In work of this kind it is very important to keep a daily detailed diary of what was done, of the problems that arose

and how they were settled. Much of the valuable material in research work is lost by the neglect to keep this detailed record of the work. The records of all research today should be so up-to-date and detailed that another worker could take up the work tomorrow and carry it on. The activities from this study may be classified under the heads used by the "Teacher Training Study." This is another bit of evidence which indicates that their classification of type activities is probably complete. The headings in the "Teacher Training Study" that are of no more concern to science teachers than any other teachers are dropped from our study. The activities of a science teacher in "recording and reporting census information" would not be different from those of any other teacher. Let us now turn to a consideration of some of the uses that are being made and that may be made of the list of activities that are of importance to science teachers.

The list is being used to check our course in special methods. The check list of the "Commonwealth Study" with the type activities further analyzed into the more specific activities performed by science teachers is first checked against the topical outline of the course. The next step is to rate the activities on the check list according to the amount of emphasis given the particular activity in the course outline. The next step is to compare this rating with the rating of the same activities as given in Table E of the "Commonwealth Study."[3] If an activity which has been given much time and attention in the course is ranked low in Table E, the activity does not receive so much emphasis in the future. If, on the other hand, an activity which has been given little attention in the course is ranked high in Table E, the activity is given more emphasis in the revised course. The list of activities is being used to develop units of the course in the teaching of science, when the units deal with the teaching of specific subject matter from a text book. It is probable that teachers should get away from the habit of confining themselves to a single text book. For a good while to come, however, the ordinary classroom teacher will confine herself pretty largely to a single text.

For work of this kind a unit of subject matter from a science text book is selected. Let us assume that Project IV,

3 Op. cit., pp. 621-646.

in "The Science of Everyday Life" by Van Buskirk and Smith is selected for study. This project deals with bacteria. The first step is to analyze the subject matter of the unit in great detail. Next the detailed objectives for the unit are listed. Next, by the use of the check list of pupil activities, the pupil activities, that seem desirable in attaining the objectives set up with the subject matter at hand, are decided upon. In our activity list we have separated the pupil activities from the teacher activities. The following pupil activities will serve as examples of the twenty-five decided upon:

A. 1. Development of useful interests. worthy motives, and sincere appreciations.
   a. Appreciation of the work of scientists in their war against germ diseases.
   b. Appreciation of the laws of science—the operation of the law of cause and effect.
   c. Interest in personal good health.
   d. Interest in community health.

* * * * * *

A. 6. Improving the skills and abilities (classroom).
   a. Using the microscope.
   b. Reading science material intensively and extensively.
   c. Making graphs.
   d. Making tables from statistics.
   e. Interpreting tables and graphs.
   f. Collecting material.
   g. Making reports.
   h. Making culture media.
   i. Mounting slides.
   j. Sterilizing.
   k. Giving attention.
   l. Making drawings.
   m. Keeping course books.
   n. Making surveys.
   o. Illustrating.
   Etc.

The activities after the Arabic numerals are type activities from the "Commonwealth" list. The activities after the small letters are the more specific activities supplied by our list which applies specifically to science teaching.

The next step is to make a list of teacher activities by use of our check list of teacher activities, that seem necessary in order to have the pupils carry on the desired activities in the classroom. From this list of teacher activities a few are selected that seem important and difficult. These few important and difficult teacher activities become the teaching problems for that particular unit. The following problem is given as one example:

2. How to arouse interest in the subject-matter of the unit?
   (a) How anticipate specific interests that might be fostered by work on the unit?
   (b) How present the materials of the unit most attractively before the pupils have started to study them?
   (c) How stimulate and direct exchange of views among the members of the class to the end that sincere appreciations may be shared and intensified?[4]

After the teaching problems are located, specific classroom situations in which each of the problems occur are collected. These situations, then, are typical of those that may be met when the teaching activities decided upon are applied to the pupil activities of the particular unit. The pupil activities are the ones best calculated to bring about in the pupil the change in behavior implied by the objectives set up. The next step is the finding of ways in which the teaching situations can best be met. In this work the literature is read, principles of Educational Psychology which apply are studied, interviews with experienced teachers are made, and the experimental data, bearing upon the situation are studied. In some cases it is difficult to harmonize what we get from the principles, so-called, of Educational Psychology with what we learn from the experimental data at hand. The check list of pupil and teacher activities of the "Commonwealth Study," with the type activities analyzed further into the more specific activities pertinent to science teaching and with the ratings of the type activities by science teachers for frequency, importance, difficulty, and desirability of teaching in teacher training institutions available, furnishes an excellent starting point for the development of tests for science teachers.

In an effort to initiate the matter of making tests for science teachers, Dr. Waples and the writer have constructed a preliminary edition of a "Classroom Procedure Test in Natural Science."[5] Classroom situations, problematical in nature, were collected from teachers of high school science. From this large group of problematical situations, those were selected which involved activities that had a high composite rating in the "Commonwealth Study." From this more restricted list of situations, ten were selected on which there are some objective data available. "The ten situations are described in separate paragraphs, each of which is followed by five possible ways of meeting the situation. The test consists in selecting that one of the five procedures that is best supported

4 Op. cit., pp. 179-180.
5 Waples, Douglas and Cunningham, Harry A.—"Classroom Procedure Test in Natural Science." The University of Chicago Press.

by experimental evidence and the one procedure most directly conflicting with such evidence." The following copy of test No. 9 will give some idea of their nature.

TEST NO. 9.

DIRECTING LABORATORY WORK

A certain teacher wishes to plan a method of conducting laboratory work in general science that will best supplement other methods of instruction. The other general science teachers in the system have various ideas as to what type of laboratory instruction should be given. Some are teachers of the special sciences and consider that science must be taught by means of much individual laboratory work. Others think that most of the laboratory work had better be done by lecture demonstration in the general science classes. The teacher might adopt any one of the following procedures:[1]

1. Make extensive use of lecture demonstration methods to furnish a knowledge of science subject-matter and provide enough experimental work to give initial training in laboratory procedure.
2. Use the individual laboratory method exclusively in order that the training may be more intensive and hence of more lasting value.
3. Use the lecture-demonstration method exclusively in order to acquaint the pupils with a wider variety of significant science principles.
4. Use the individual laboratory method exclusively because better immediate results are obtained with the least expenditure of time and money.
5. Divide the time equally between the two methods, following each lecture-demonstration by an appropriate individual laboratory exercise.

DIRECTIONS:

(a) Write the number of the most efficient procedure.....
(b) Write the number of the least efficient procedure.....

This list of teaching situations is probably of more value as a teaching device than as a test. After the test has been taken and the papers scored and returned, it becomes the basis for valuable discussion. The discussion will be supplemented by a study of the references given below the test and any other references bearing upon the situation. This test will be revised and extended. In extending the test to cover other important problems of science teaching, as determined by the "Commonwealth Study," the scoring cannot be determined at present by objective data but by a concensus of the opinion of experts. We need more and better objective data to focus upon these problems.

1 Scored with reference to the finding of studies by F. G. Anibel, "Comparative Effectiveness of Lecture-Demonstration and Individual Laboratory Method," Journal of Educational Research, XIII (May, 1926), 355 ff.; W. W. Carpenter, "Certain Phases of the Administration of High School Chemistry," Teachers College, Columbia University, Contributions to Education No. 191 (1925); J. L. Cooprider, "Oral versus Written Instruction and Demonstration versus Individual Work in High School Science," School Science and Mathematics, XXII (December, 1922), 838-44; H. A. Cunningham, "Laboratory Methods in Natural Science Teaching," School Science and Mathematics, XXIV (October and November, 1924), UPO-15 and 8R8-51; Kiebler and Woody, "The Individual Laboratory versus The Demonstration Method in Teaching Physics," Journal of Educational Research, VII (January, 1928), 50-58; W. W. Knox, "Demonstration versus Laboratory Method of Teaching High School Chemistry," School Review, XXXV (May, 1927), 376.

Measured Outcomes of Laboratory Instruction

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In this paper[1] there will be described some attempts to measure outcomes from laboratory work in chemistry which are not revealed by written examinations. The investigation was undertaken to arrive at a satisfying answer to the question of what to do with the laboratory period. Individual laboratory work has long enjoyed a prominent place in our chemistry teaching but has recently been the butt of severe criticism. With abundant opinion, a wealth of authority and long traditions supporting our practices, there seemed to be few reliable facts from which to decide what contributions are really made by the various elements of this practice. We wished to know definitely what changes in pupils resulted from their laboratory work and from this knowledge to decide how best to employ the laboratory in realizing the goals of science instruction.

The problem was approached from the point of view of a chemist rather than that of an experienced educational investigator. Many of the technics will perhaps appear crude on this account. With more or less skepticism about statistical substitutes for the burette and chemical balance, it seemed, nevertheless, that the criteria for arriving at truth must be the same in any field.

Now the task of determining the relative yield of a given product from two or more processes in chemistry would consist of weighing the raw materials at the outset; of making sure that the samples were of equal quantity and purity; and of carefully controlling the processes as to temperature, time, agitation, contact agents and the like so that every influencing factor was accounted for. Emulating this ideal, consciously, we took pains in this experimental study: *first,* to insure the equality of the original samples; *second,* to vary only one condition in each sample; *third,* to keep out or equalize all other conditions which would affect the product;

1 Read at the December meeting of the American Association for Advancement of Science, Section Q.

fourth, to maintain a control; *fifth,* to measure the product in units defined and comparable.

At the outset, also, it became necessary to grasp the concept which to this audience will appear very elementary, that in educational measurements it is absurd to expect to get two individuals equal in any respect whatever, and that the samples for study must be groups of students individually different but so selected that the groups as a whole are equivalent in potential ability. Not only does it appear to be impossible to get individuals equal, but if we consider any single individual and the changes occurring in him we cannot be sure that any observed change is due to any single factor nor can we verify results by repeating the test on this individual. He can never again be free from the effects of each experience. Thus attempts to apply chemical methods to educational experimentation meet with obstacles.

The data for this study were gathered in one school — the Seward Park High School, New York City. This seemed to be consistent with the aim to make the study comparable to a chemical investigation, in which careful controls must be maintained and in which variations of conditions would invalidate the data. Previous experimental studies of science practices in which data have been collected from various schools have aroused serious doubts as to the uniformity of experimental conditions with consequent justifiable skepticism of the inferences made.

The customary practice in this school at the time of the study, conformed to the requirements of the State of New York and the results of the instruction in terms of Regents' Examinations seemed to indicate that this practice was representative of that in general use. Full description of this practice is given in the published report of the study.[2] While the Equivalent-groups Method was used for much of the study, this was checked by using different bases of equating and again by the Rotation-groups Method. Each verification required new groups of students, other teachers and a full term of work. The investigation, therefore, extended over a period of three school years and involved some 2500 pupils. With the precautions taken for control and for verification there-

2 Teachers College, Columbia University, Contributions to Education, No. 303.

fore, it is believed that the picture of the situation and the outcomes of laboratory work present the truth for this school. They will be true for other schools in the measure that our practice is typical.

The first measurements were in terms of written examinations. Comparisons were made between groups of students instructed by the demonstration method and by the individual method, both following directions printed in a laboratory manual. Individual laboratory work here means that each student individually handles chemicals and apparatus and observes the happenings. In demonstration laboratory work the teacher performs the experimentation before a group of students who passively observe the happenings. The groups were first equated on the basis of Biology marks which had been found to give higher correlation with Chemistry marks ($r = .54 \pm .04$) than did intelligence tests. On the next trial, we equated on the basis of a preliminary test in chemistry and further verification was obtained by the Rotation Method. Classes were instructed by various teachers and each compared group contained a fair sampling of pupils from all teachers. The tests were given after nine weeks' instruction (the Midterm Examinations) and again after 18 weeks' instruction (the Final Examinations). Table I gives the summary of the results of these written tests for two different years. In all of these written tests it can be seen that the individual method gives slightly better results but that the measure of reliability — the difference of the means divided by the sigma of the difference does not in any case meet the requirements of practical certainty.

These data which are consistent in four different trials may be interpreted in two ways: either there is little or no difference between the effects of the methods of presenting the experimental work; or the written test is an invalid instru-

TABLE I

Results of Written Tests

Test	Number		Mean Score		Diff.	Diff.
	Lab.	Dem.	Lab.	Dem.		S. D. D.
A	379	85	77.75	72.60	5.15	2.51
B	351	85	43.60	40.95	2.65	2.09
C	128	63	41.08	39.30	1.78	1.63
Rot.	43	43	17.51	13.16	4.35	2.52

TABLE II AND TABLE III (Combined)
Results of Individual Performance

TEST I

Group	Mean	Diff.	S. D. D.	Diff. / S. D. D.
Dem.	9.95	....	....	....
Indiv.	12.83	2.88	.58	4.96

TEST II

Group	Mean	Diff.	S. D. D.	Diff. / S. D. D.
Dem.	19.75	....	....	....
Indiv.	26.58	6.64	1.58	4.20

TABLE IV
Results of the Group Performance

Group	Mean	Diff.	S. D. D.	Diff. / S. D. D.
Dem.	32.00	....	....	....
Indiv.	52.57	20.57	6.45	3.19

Note: 43 pupils in each group.

ment for detecting such differences as may exist. Previous studies have concurred in assuming the former to be the truth but in this study the hypothesis was made that other outcomes might exist which the written test could not detect or measure.

With this hypothesis, we attacked next the problem of devising means of measuring in other ways. It seemed reasonable to suppose that changes in pupils would appear, if anywhere, in abilities to understand and manipulate apparatus or in setting up and doing actual experimentation in the laboratory. After several false starts, two forms of tests to measure such abilities were devised. One has been called the Individual Performance Test; the other the Class Performance Test. Both require the doing of tasks in the laboratory with apparatus and both provide for scoring objectively, this performance. A sort of job-analysis method was used to secure the units for the first test. The performance of

teachers one at a time was observed by other teachers who made a sequence of the procedures used. The essential items in these lists were incorporated into a scoring sheet with 20 items. For example, in preparing oxygen which was one of the test topics, the first ten items were:

1. Selects Potassium Chlorate.
2. Selects Manganese Dioxide.
3. Mixes substances on paper.
4. Prepares delivery tube correctly joined.
5. Fills bottle with water.
6. Puts water in a pan.
7. Selects a dry test-tube.
8. Holds the test-tube in a holder of some kind.
9. Inverts bottle of water with hand or glass over its mouth.
10. Heats the tube slowly at first by moving either the flame or the tube.

The scoring sheet with twenty items for each preparation was held by the examiner. The pupils were examined individually and privately. The task was typed and read to the student by the examiner. One task was, "Prepare and test one bottle of Oxygen using the chemicals and apparatus before you on the table. . . . Proceed exactly as you have been taught. Work rapidly but take all necessary precautions and clean up when you are through." The pupil did not know before or afterward on what points he was scored and as we had several topics of equal difficulty, there was no opportunity for coaching one another. Two hundred pupils were examined in these individual performance tests with an average time of fifteen minutes taken for each.

Tables II and III present the data from these tests. The second test consisted of 36 items. These were validated by the method of job analysis and by analysis of 15 laboratory manuals. To be quite sure that these technics were those in common use the list was evaluated by 16 specialists in chemical education.

In table II the difference in the mean scores of the two groups is 2.88 score points from a total of 20. The reliability of this difference is 4.96 times sigma in favor of the individual method as contrasted with the demonstration. In table III, the individual laboratory method yields an average achievement score which exceeds that of the demonstration by 6.64 in a possible 36. The reliability is measured by 4.20 times sigma which is lower than the preceding but which could have been easily raised by taking more cases.

As this form of test required so much time — about nine

hours to test a class of 35 members — an effort was made to devise a technic of testing the same abilities in class groups. A tentative form of such test was attained by taking fewer items and by increasing the number of examiners. The first use of this form was made with two groups instructed on the topics Ammonia and Nitric Oxide by rotating the individual and the demonstration methods. The topics were analyzed into 7 items which were written on library cards by the pupils and kept in front of them during the experiment. Directions were given orally as before by reading a typed form. As each pupil completed a step in the procedure he raised his hand. A proctor thereupon went to him and marked on the individual card the score as right or wrong and the time of completion. From these cards were obtained an individual score and a class mean in terms of both quality and speed of performance. With several proctors using a key for scoring, a class of 35 can be examined as to ability to perform an experiment with objective scores in forty minutes. Table IV presents the results of the test described. The means are in terms of an "index" which combines both speed and excellence. The difference in the means of the two groups is in favor of the individual method and verifies the results of the individual performance test. We can be practically certain that in these tasks the training by individual method was superior.

Similar tests can be made with any laboratory task. The technic consists simply in analyzing the experimental work into as many unit procedures as can be scored by a given number of proctors in the available time. The class tests show less reliability than the individual tests — no doubt on account of the fewer items — but this is compensated for in the larger number of students that can be examined in a period. Both forms appear to be valid and reliable instruments for measuring some of the manipulative abilities or skills which are presumed to be acquired in a course of chemistry. From these data then it seems safe to infer that, *first,* there are outcomes of laboratory work not revealed by written tests; *second,* these outcomes are of the nature of manipulative, practical nature; and *third,* the pupils trained by individual practice acquire such abilities better than those who have passively watched the teacher-demonstration. It ought to be said that these inferences may not be generalized to apply to every school but only to those of which our practice is typical.

PART II. THE PROBLEM METHOD

With this evaluation of the individual and demonstration methods of laboratory work as traditionally administered, we next faced the question, "Does this practice of sending pupils to the laboratory to follow directions and to learn to manipulate, exhaust the possibilities of the laboratory period?" Another year was spent in experimenting with several proposals for modification of current practices. One of these proposals appears to offer possibilities of usefulness in realizing one of the very important goals of science instruction, namely training in scientific thinking. It has been suggested that a brief explanation of the method and the experimental data on which it was based should be reported to this group.

In recent years the term "Project" has become a label for multifarious schemes of instruction in General Science, Biology, Physics, Nature Study, Shopwork and finally in Chemistry. Many of these systems bear little likeness to the concept of the "project" as conceived by its early sponsors, Dewey and Kilpatrick. But even the best of these proposals have failed, somehow, to enlist the support of the majority of our science teachers. Likewise these methods — certainly in chemistry — and probably in all our science subjects except general science have failed to break down the traditional, logical organization of the subject matter. While this is due in many cases to super-imposed authority, yet it is evident that organized science has the field and that it has yet to be shown that the principles of chemistry — a system, avowedly — can be inculcated by "scrapping" the organization of the material. With full apprehension, then of the apparent conflict, we undertook to harmonize the aim, on the one hand, to teach to think, with the unavoidable situation, on the other, namely, maintenance of logical organization.

It is evident, however, that any attempt to give instruction in scientific thinking or to solve problems involves many controversial questions of psychology such as the nature of intelligence, transfer of training, conditioned reactions, generalized habits and the like. It appears, nevertheless, that in chemistry, in common with other fields of study, we do expect that what is learned in school will function somehow outside of school in situations involving this subject matter. We certainly hope, at least, if not fully believe, that a course of science in high school will be helpful as a preparation for col-

lege science. Now this may be a belief in "transfer of training" which this paper is not designed to define or debate. Whether or not it is a belief in transfer; likewise whether or not transfer when properly defined is psychologically sound — at all events, — psychologists seem to have pretty well established that the best way to be sure to know how to do anything is to practice doing that thing. It seemed then, that if we seriously desired pupils to know how to *do* tasks in chemistry: to set up apparatus, to find out information for themselves, to make experimentation for the purpose of verifying or disproving assertions or assumptions, that we ought certainly to give them practice in this kind of task.

"The Problem Method" then is the name adopted for its descriptive value and for lack of a better term. It is employed in this study in conformity to its usage in Bulletin No. 26, Reorganization of Science in Secondary Schools, Bureau of Education, Washington, 1920. It labels a method designed to use the chemical laboratory for training pupils to think through and to do the kind of tasks demanded by our accepted syllabuses; namely those of the American Chemical Society, the College Entrance Board and the New York State Board of Regents.

It has been facetiously said that, in spite of the teachers, some pupils do learn to think. Psychologists have not yet finished analyzing an act of thought. There is divergence of opinion as to the processes involved; yet there is practically general belief that improvement in ability to think, must come, if at all by conformity to the laws of habit formation. It seems probable that good and poor thinking habits are established very early in the child's life. By the time the high school level is reached, these are well fixed. Long experience in accepting authoritative — parental, teacher or other adult — judgments seems to breed docility and lack of initiative in the face of difficulties. Thus we find our beginning science students in high school memorizing definitions, explanations and descriptions. They seek to find answers to their home-work questions all ready-made on some line of some page in the text-book. In the laboratory they customarily follow directions. At any rate they are supplied with manuals containing directions and after another period of conditioning they — some of them — learn to read and follow these directions. The meaning of the experiment becomes clear — if at all — in the

subsequent class-room period through the interpretation or demonstration by the teacher.

This picture of the situation may not be universal: it is certainly very general. "The fact that laboratory work," says Bulletin No. 26, "in general has not accomplished the results expected indicates the need for reorganization of method." On the hypothesis that learning *to think* and *to do* could be achieved — if at all — only through *opportunity to think and to do* and that the laboratory gave this opportunity, an experimental program was devised to test the proposals and to measure the results in an objective way.

(*To be continued*)

Are "Cool" Colors Cool?

The psychological effect of color is a subject that has been carefully studied in recent years. It is now accepted as a fact that people are influenced one way or another by different colors..

The so-called "cool" colors not only seem cooler, but are actually cooler. This is illustrated by the influence of white paint on temperature. A white surface acts like a mirror. White ships in the tropics are known to stay five or six degrees cooler than black ships.

The temperature of the interior of structures in summer months depends to some extent on the color of the exterior surface. Most uncoated structures will be warmer in the summer months than structures painted in white or light tints. This principle is recognized in tropical countries, where many structures are finished white.

Experiments conducted a few years ago show the difference in temperature of the air in metal containers painted with different colors. The following table, taken from an article by Dr. Henry A. Gardner, shows the result of the tests:

	Air in Metal Structure ° F.	Interior of Wood Panel ° F.	Interior of Iron Panel ° F.		Air in Metal Structure ° F.	Interior of Wood Panel ° F.	Interior of Iron Panel ° F.
Not Painted	102	114	126	Painted Gray	110	122	120
Painted White	102	104	106	Painted Blue	108	120	122
Painted Cream	103	110	110	Painted Green	109	124	126
Painted Orange	107	118	118	Painted Black	114	130	130
Painted Red	108	126	122				

How the University May Help in Training the Nature Teacher

W. B. Baker, Professor of Biology
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In a discussion of the meaning of the nature study movement, Prof. L. H. Bailey says— "It is one of the marks of the progress of the race that we are coming more and more into sympathy with the natural world in which we dwell. The objects and phenomena become a part of our lives. They are central to our thoughts. The happiest life has the greatest number of points of contact with the world, and it has the deepest sympathy with everything that is."

With this idea I think all of us are in hearty agreement and I think also that we will agree that the chief credit for stimulation and development of this sympathy with the natural world should go to the sponsors and teachers of nature study in our elementary schools. As we examine the end results of this teaching as manifested in the educated pupil as he takes his place as a citizen in the community, we must pay tribute to those inspired teachers who have made this important contribution to our general program of education.

Nature has ever interested man. In his primitive state of living he held the forces of nature in abject terror. The flash of the lightning, the peal of thunder, the floods, the droughts, the forests with wild beasts — all filled him with awe. Even today, among savage races, sacrifices are offered to appease the wrath of the angry powers which operate in nature.

Later as he became more familiar with the objects in the natural world, he realized that they were things of much interest, but quite separate and apart from himself and in no way related to him. Continued observation and experience however, caused him to appreciate many objects and forces as being able to yield him profitable returns and serve his specific needs. Such was the buoyancy of water, the heat of fire, the warmth of animal skins, the flavor and nourishment of various fruits and leaves.

With the accumulation of information regarding other creatures around him, the animals he domesticated, the plants he selected for his food, he saw that their life processes were

quite similar to his own. They showed the same physical needs for food, water and protection. The regularity of the seasons brought about much the same effects in their existence as in his own. He began to adjust his activities more and more in accord with the changing environment around him. In short he began to look on nature as an environment of which he was a part, governed by regular and dependable laws which affected all living creatures.

His increasing knowledge was passed from generation to generation and with the development of his educational systems and institutions, he came to evaluate anew his traditions, his customs and practices, the sources and nature of his information, and the relationship of his activities to the knowledge of the universe around him. He cast aside that knowledge which served no particular need and pushed forward into new fields which would yield satisfactory returns. He soon came to realize that nature was a teacher par excellence. She could instruct him in the laws of living; she could impart to him useful knowledge; she could show him what to do and how to do it; she could show him what to be and how to be it. Burbank expressed this aspect of nature in his last book:

> "If we go back far enough we find that everything we study, learn and know, and all the facts from which we build our theories, and even our Dogmas, come from Nature's own book. . . . That is why science is at once the most fascinating and the most basic subject we have to ponder, since science teaches us the laws and practices of the natural world, whether of man or animal, of flower or tree, of air or water, of earth or star, of physical property or of mental process." (*The Harvest of the Years.*)

Having arrived at this conclusion regarding nature it is not strange that man should have begun to insist that what he had learned from contact with such a teacher be imparted to his children. He began to establish laboratories for investigation of nature's secrets and universities for the dissemination of the findings. He organized programs of teaching which should begin in the elementary grades and continue progressively through the high schools and colleges until a thorough understanding of nature might be accessible to every student.

It should be considered a privilege to be given a part in carrying forward such a program which has for its objective the bringing of more boys and girls, more men and women,

to the class room of this our most reliable and authentic teacher.

> And Nature, the old Nurse, took
> The child upon her knee,
> Saying. "Here is a story-book
> Thy Father has written for thee.
> Come, wander with me," she said,
> "Into regions yet untrod,
> And read what is yet unread
> In the manuscripts of God."

Certainly our universities should and do have a part in the nature study movement. The part that they may take in the training of the nature teacher is the subject we are to consider this afternoon.

The most important element in carrying out any educational program is the teacher. He is indeed the key to the educational situation. His responsibility is especially great and his importance is to be particularly emphasized when new ideas and projects are inaugurated. The success or failure of the nature program rests largely with him.

A few characteristics of the successful nature teacher should be considered before we can discuss intelligently the part the university can play in his training.

(1) The teacher should have a pleasing and attractive personality, a keen imagination, great personal enthusiasm, and not be so bound by methods that his teaching lacks freshness and vigor.

(2) He must have a sincere and well-grounded appreciation of nature, together with a wholesome personal outlook on life and the natural world with all its objects and phenomena.

(3) He must be trained to observe accurately, correlate carefully, and draw conclusions correctly; in brief, to use the scientific method of thinking.

(4) He must be thoroughly familiar with the facts as related to natural objects and phenomena. He must likewise know the principles which operate throughout nature, as illustrated by individual objects of interest and significance in the great out-of-doors.

(5) He must be able to teach and inspire his pupils from an abundant reserve of information and enthusiasm. No current can flow except from higher to lower levels. No teacher can inspire his pupils unless he himself is well grounded in

the facts of his subject, has a deep and abiding faith in its value, and has an abounding enthusiasm for presenting it.

It is perhaps true that the nature study movement originated in the elementary school and has worked its way upward into the high school, the college and the university. It has been said in fact, that the movement had its origin as a reaction against the "dry as dust" science teaching in the university. If this be true, it would seem that the higher institutions are subject to criticism for having permitted some of their most attractive subjects to get into disrepute. Certainly the college and university professors should make a careful study of the situation and see to it that the "dry as dust" courses in the sciences be revised and reorganized. As a matter of fact, there should be such close cooperation and coordination between the various elements of our educational system that such reactions and revolts need never occur.

The university has a distinct obligation with regard to the elementary and high schools. Even though they are parts of different systems and maintained by different agencies, their fundamental objectives are the same. They should work in the closest harmony. It should be the concern of every college and university professor and executive to find how he can best aid the lower schools in the solution of their problems. It is certainly true that the effectiveness of higher institutions is largely dependent upon the type of work done by the elementary and high schools.

First, regarding the training of a nature study teacher, the university should give a thorough grounding in the use of the scientific method of thinking.

Experience has shown that observation of given phenomena, correlation of observed data, and experimentation in order to check the conclusions deduced, is the safest and most accurate method of discovering truth. Exhaustive knowledge of science is not a prerequisite of a nature teacher, but it is most essential that he be able to use the methods of science. These methods are not limited to the truly scientific fields. They are equally as good in other phases of intellectual endeavor. Hence the pupil who has been properly trained in nature study under a teacher who uses the method of observation, correlation and experimentation is better able to cope with any of the problems of life which he is called upon to face.

To be sure the child in the elementary schools is too immature to use the scientific method in its entirety and yet from his earliest years he can be trained to see that effects follow causes, that complex and little understood phenomena can be simplified and be made a part of his individual experience, that all the universe is governed by laws which are orderly and by forces which are accurate and unchangeable. In this way he may be trained unconsciously to use the correct method of thinking.

Second, the university should impart thorough knowledge of nature and of natural phenomena to the prospective teacher.

Emphasis has been placed in the past on the statement that the teaching of nature study means primarily the stimulation of a love for nature in the mind of the pupil. Likewise it has been said that the most important mark of the successful nature teacher is a great love for nature. Have love, teach love and let the knowledge take care of itself. Because of this attitude much of nature fake has crept into our teaching. An example of this sort of thing is to be seen in the widespread teaching of a use for every structure found on plants and animals. An attempt is made to explain every spine, every hair on leaf and stem, the presence of poisons in the plant as definitely developed protective mechanisms. The various accidental relationship between structure of flowers and insect visitation are interpreted as perfect adaptations of means to ends. The broader meaning of adaptations as seen in living organisms is usually lost. Here indeed the truth would be stranger than fiction.

Granting however, that a love for nature is necessary in the nature teacher, the fact remains that we do not love those whom we do not know. Before love can come we must not only be acquainted with the objects of our affections but must know something of the detailed characteristics and qualities of their individual personality. We do not love so blindly as some would have us believe.

I recognize the fact that a course made up of a mass of facts to be memorized by the student usually creates in his mind a dislike for the subject. "Mere facts are dead, but the meaning of the facts is life." Of all the courses in the university curriculum, the sciences may be made the most interesting to the average student. Every advantage of the

visual, experimental, and laboratory methods of teaching is available in this field. The teacher who does not make full use of such aids in familiarizing his students with the laws or facts of nature is neglecting an excellent opportunity.

Nature study without a solid foundation and background of truth and fact is superficial and hazardous. I do not mean to imply that the teacher must be a master of every field of natural science, but that he should have a reserve of information from which can flow a vigorous and spontaneous current of interesting things, which will stimulate the pupil's interest, command his respect, and arouse within him a love and an enthusiasm for the great out-of-doors which will be far reaching and continuous.

In order to acquire this background of information the prospective teacher should be required to take at least introductory basic courses in each of the natural sciences and then advanced courses in the particular science in which he becomes most interested. I do not think emphasis on methods of teaching is nearly so important as many would have us think. Professor Bailey says: "The best training is to acquire the actual facts and to know the subject, then go out and teach without too much burden of doubt as to the kind and propriety of the theoretical methods."

Third, the university should lead the way in the investigation of the problems regarding natural phenomena which give to nature study a firm scientific background.

There are those who draw a sharp line of distinction between science and nature study. They attempt to make science cold, impersonal, and uninspiring. On the other hand they would have us believe that nature study alone is inspirational, is a matter of heart rather than head reactions. The one is a matter of cold intellectual interest; the other a matter of warm and comforting love and adoration.

As a matter of fact, nature study and science are not mutually exclusive, but rather useful and important adjuncts. True science is not mere classified knowledge as usually defined. It is rather the search for and study of the truths of the universe around us. Scientific study has had a great influence on the life and mind of man. It has touched him in more intimate and personal ways than perhaps any field he has entered. It has freed him from superstition; it has increased

his material comforts; it has given him greater leisure to think; it has increased his self-reliance and his self-respect. "He stands erect before Nature and through a penetration of her secrets, commands her to do his bidding, then comes to a loftier appreciation of her Creator." Speaking of the research scientific laboratories, Louis Pasteur said, "They are the temples of the future, of riches and of comfort. There humanity grows greater, better, stronger; there she can learn to read the works of Nature, works of progress and universal harmony, while humanity's own works are too often those of barbarism, of fanaticism and of destruction."

To the rational mind, truths are only satisfying when solidly grounded on observed facts. A teacher can have little enthusiasm for teaching nature study unless he feels the genuine satisfaction of facts acquired from a solid foundation. Such a foundation can only be provided by patient and persistent research.

Imagine the type of nature study we would be forced to teach if we were asked to discard the results of the scientific research of the last few centuries. We would still point out the tree whose fruit if it fell on the ground would turn into worms, if into the water, into geese. And with enthusiasm we would sing, "Baby bye see the fly. How he crawls up the walls, yet he never, never falls." The stars would still be governing our destiny; the moon would still be watering our crops; the night air would still be producing malaria; our diseases would still be the result of the indwelling of evil spirits.

The university should have for one of its most important functions the carrying on of research.

Fourth, the university may help in training the nature teacher by interpreting the facts of nature for him so that he in turn may be able to inspire the proper attitude toward natural laws and toward life in the minds of his pupils.

The acquisition of facts is the mere beginning of an education. If there has been a reaction in the elementary schools against the "dry as dust" science teaching in the university, it is largely due to the fact that the university courses have become masses of fact to be memorized by the student. It is interesting to know how many bacteria may be lodged on the point of a pin, but it is far more important to know

what it means to prick a pimple on the face with that pin. It is interesting to know the number of miles from the earth to the sun, but it is far more significant and inspiring to know the importance of the life-giving rays which come from the sun to the earth. It is interesting to know how much carbon dioxide is given off per minute by the human body, but far more significant to know the marvelous economy of nature by which the carbon dioxide is transformed into life-giving food by the action of green plants in the presence of sunlight.

It is often said that the province of the philosopher is to interpret the findings of the scientist and weave them into the total fabric of human knowledge. I cannot agree with such an attitude. Unless the scientist is broad enough in his viewpoint, sufficiently well trained and thoughtful enough to give to his students an interpretation of the facts of science, his work and worth is considerably limited.

"The object of science is, or ought to be, not merely to describe phenomena and to sort and label them, but to perceive their intellectual relation; and that means to perceive the Infinite Intellect which has prearranged them and is revealed in and by them."

Fifth, in training the nature teacher, emphasis should be placed on the materials found in the local environment. The courses should familiarize the student with these materials by field trips, laboratory observations, and correlated discussions.

To be most effective, nature study should be made to include those things that are most common in the experience of the child. An examination of the texts and reading references in use in many of elementary schools, shows materials listed and discussed as types which are found in localities remote from the one in which the pupil is working. This is especially true of biology. In the desire to make the biology of the college and university different from that of the lower schools, resort is too frequently made to pickled specimens. It is not strange that some have recently defined biology as the science of life with the life left out. It is not unusual to find a course in which no living specimen, plant or animal, is presented to the student. Needless to say, such a course fails to arouse much interest, or instil much respect, or inspire much love in him for nature and natural objects. He comes to think of the course in terms of the odor of formalin and of preserved fish and frogs.

In contrast, however, are those courses given by teachers inspired by the marvels of living phenomena, thoroughly conversant with living things as they occur in the natural habitat, and imbued with love for Nature and Nature's God.

From the first lecture and laboratory period, in the field, in the classroom, in the laboratory, laws of life as found in living plants and animals, are presented to the student. The moss, the fern, the tree, the flower, the insects, the frogs, the birds, are considered, one after another in all their relationship to each other and to their environment. The forest as well as the trees are seen.

Students go from such a course not only with a knowledge of living creatures but better still a knowledge and appreciation of life. The university should insist upon such course as training for the nature teacher.

Sixth, the university should maintain in connection with its various departments a museum of materials of local as well as of general interest.

No more important adjunct to nature training can be found than a well-organized museum. Not only can the teacher become acquainted with a much wider range of materials in the museum but he can likewise depend upon it for the identification of new materials which he and his students find in their nature work. This phase of activity, of course, presupposes the accumulation of files of taxonomic reference works, as well as some training in their use by the student.

The teachers should be encouraged to make the museum a depository for collections from their own localities. The thrill of discovery and identification of some new type of plant or animal more than repays hours of tedious collection.

In connection with the museum as complete an herbarium as possible should be provided and as many trees, shrubs and plants as practicable should be kept growing in an arboretum or botanical garden. Here first-hand knowledge can be had from the growing specimens.

Seventh, a great deal of emphasis should be given to conservation programs as related to the wild life of a given region.

Man, in his zeal for conquest and wealth, has made many mistakes in the past. He has killed off the birds and his crops have been devastated by insects; he has cut away his forests and his soil has been robbed of its vital nutritive elements;

he has polluted his streams and has caused great damage to his fisheries. Nature enthusiasts have sounded a warning as to the results of such practices, but not until recently has the public at large shown much interest or concern in the matter. Much yet needs to be done, if we are to pass on to posterity a country dotted with beauty spots unspoiled by the lumberman's ax, the stockman's cattle, or exploited by other private interests.

The university should co-operate to the fullest extent in the national park movement, in the preservation and reforestration projects, in the conservation of the wild animals and plants, in the campaigns against the pollution of lakes and rivers. In no better way can we co-operate than in the training of the nature teacher. For after all, the real success of the conservation programs depends largely upon education and the building of a sentiment in that direction. Dr. T. Gilbert Pearson, of the National Association of Audobon Societies, said in a recent address:

"Our great duty as conservationists is to acquire all possible knowledge on the subjects involved and pass this information along in campaigns of education. It is clearly our duty to lay hold of the many promising openings for service, and to co-operate in every honorable way with every agency to invade the realms of ignorance and indifference."

Finally, as a part of the help the university may give in training the nature teacher, it should provide a contact man between the elementary schools in which nature study is taught and the departments in which nature teachers are traind.

It is difficult to outline definitely the duties incident to such a position. The individual who fills the place should act in the capacity of adviser rather than supervisor. He should be first of all a scientist of broad training and proven teaching ability. He should be sympathetic with the problems of the teacher in the elementary and high schools and should have a keen appreciation of the relationships of the sciences to the ordinary affairs of life. He should be experienced in the technic of research and know the fields in which the most interesting and enticing problems are to be found. In addition he should be thoroughly familiar with the materials found in the area influenced by his university.

His work should be both in the field and on the campus. In the field he should assist in every way possible in carrying out specific nature study programs. It is recognized that nature study should not become stereotyped either in content or method of presentation. The adviser should therefore assist each individual teacher with local problems, such as the selection of most appropriate local materials, formation of specific projects, organization of the work in the different grades, and the possible correlation of nature study with the other subjects of the curriculum.

On the campus, the contact man should be charged with the organization of college programs which have nature teaching as their chief objective. The science departments should be brought into close co-operation in such programs. He should maintain close connection with the teachers of nature study through correspondence and extension courses. He should have general charge of the exhibits in the museum which relate specifically to his work. This would involve the collecting of materials from the type localities, the bringing together of exhibits from various schools for loan to the university museum, the encouragement of both teachers and pupils in the maintenance of aquaria, school gardens, and the like, for study of living specimens.

It will be seen that to fill such a place as above outlined would be quite a difficult matter, yet in perhaps no other way could the university more effectively aid in carrying on nature work.

The responsibilities borne by the university at the present are indeed grave. She should be glad, however, to assume any new ones that arise in connection with the developing educational system of her region. In perhaps no other field can she serve more pleasantly and effectively in the training of students for a higher type of citizenship, a broader and saner appreciation of life in its fullest relationship than in those represented in the nature study movement.

Suggested Programs for a Science Club

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Introduction. This discussion of the work which may be done by a Science Club in an extra-curricular activities program, is intended, particularly, for the novitiate in secondary school teaching. As the title implies, the programs herein outlined, are suggestive of what may be done, not what must be done. The acceptance of any "ready-made" program without modification to the needs and interests of the particular group of students concerned would defeat the purposes and stifle the spirit of extra-curricular science work.

Some Aims for a Science Club. Before making any suggestions as to the programs for a Science Club, one should consider the objectives toward which the various programs should contribute. Various writers on extra-curricular activities in the secondary school have set up aims for Science Clubs. These aims vary in scope from a single purpose to a very inclusive set of purposes. The manual of the West Side Junior High School of Little Rock, Arkansas, gives the following single purpose of their Science Club: "For learning interesting things about science. Lives and works of great scientists are studied."

Foster[1] lists the following objectives of a Science Club:

1. To encourage general scientific knowledge.
2. To have every member take part in the meetings.
3. To encourage students to present scientific ideas or information in which they are especially interested.
4. To stimulate keener interest in the work of the regular class.
5. To help the students do better the things they will do anyway.
6. To create an enthusiasm for scientific learning among students and by students.
7. To develop initiative, self-reliance, and leadership in this field.
8. To appreciate the importance of science in the everyday life of every citizen.

It should be the duty of the club's sponsor to guide the pupils in setting up worthwhile aims for the club. In terms of the purposes of the club and with the guidance of the teacher serving as club sponsor, the pupils should plan the programs for the various meetings.

Organization of the Club. It is suggested in the programs outlined in the latter part of this article that the first meeting of the club be devoted to effecting some form of club organization. Pupils should be encouraged to use their own initiative in selecting a name for the club and determining the officers

1 Foster, C. R. "Extra-Curricular Activities in the High School."

and committees appropriate to the enterprise. The following quotation from a letter received by the writer of this article from Mr. O. R. Davis, illustrates the use of student initiative in a Florida high school science club:

> The club organized and voted to call itself the T. N. T. Club; and the officers were called Scientist—corresponding to a president; Laboratorian—corresponding to a vice-president, with the duty of seeing that the programs were prepared; Recorder of Data, or secretary; and Toucher-Off, or sergeant-at-arms. These names were all supplied by the pupils. The club was organized into groups of four, and it was the duty of one of these groups to put on a program each week.

For a discussion of the policy to be kept in mind concerning the carrying out of programs the reader is referred to an article by Raymond Lussenhop[2] entitled, "The Organization of a Science Club."

Summary of Program Activities Suggested by Writers. The following list of activities suitable for science club programs was compiled by the writer from a large selection of articles on science club programs:

1. Current events in Science.[3]
2. Science plays and dramatizations.
3. Pupil demonstrations of striking and spectacular experiments.
4. Stereopticon and motion picture shows on science topics.
5. Biographical sketches of important scientists.
6. Lectures by persons engaged in scientific work or industrial work involving scientific processes.
7. Exhibits of scientific materials.
8. Papers read and discussed by members of the club.
9. Assembly programs sponsored by the Science Club.
10. Banquets, luncheons, and other social activities.
11. Excursions to such places as the power plant or telephone exchange.
12. "Students[4] who have visited distant lands may speak of the curious plants seen, the rare fruits of the markets may be discussed, while the spices, drugs, fibres, dyes, oils, gums, perfumes, etc., found in store and market will form an endless list of subjects for investigations in the library."
13. President of the club gives out questions to be reported upon later. The answers to the questions are to be found in Popular Science.
14. Science Spelling Match.[5]
15. Science posters.[6]

Valuable suggestions regarding desirable procedures for carrying on two of the above program activities have found their way into print. For a discussion of exhibit work for science

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2 Lussenhop, Raymond. "The Organization of a Science Club." School Science and Mathematics, 7: 461-462.

3 "The Science News-Letter," issued by Science Service, 21st and B Sts., Washington, D. C., could be used to advantage here.

4 Clute, W. N. "The High School Botanical Club." School Science and Mathematics, 12: 147-149, 1922.

5 Jacobson, C. A. "A Chemical Spelling Match." Science, 56: 368-369, 1922.

6 Jacobs, H. A. "Chemical Posters." Journal Chemical Education, 2: 792-79.

clubs one will do well to consult an article by L. C. Feldman[7] entitled, "Outside of Classroom Activities in Science." This excellent article lists a number of exhibits which students take interest in arranging. Another valuable discussion of methods of conducting phases of science club work is that of Dr. Morris Meister,[8] in an article entitled, "Managing a Science Club." In view of the fact that most writers suggest that demonstrations should form a considerable part of the science club programs, Dr. Meister suggests a method of stimulating interest and activity in this work by means of having the demonstrations center about a system of awards known as the Point System. The system of awarding points is described in full in the article.

Suggested Program for One Year. As a means of showing how the various program activities might be worked into a unified program covering a full year's work with a science club, the following program has been outlined:

Program Number	SUGGESTED ACTIVITY
1.	Devoted to effecting an organization and the discussion of plans for the future.
2.	Installation of officers. Explanation to the club of the Point System for demonstration work. Exhibit work explained. Current events in science.
3.	Devoted to the answering of questions given out at the last meeting. The answers to these questions were to be found in Popular Science Monthly.
4.	Demonstration work for securing points.
5.	Science Play—"The Wizard's Dream."
6.	Excursion to the power plant.
7.	Demonstration work for securing points.
8.	Exhibition and explanation of various Science Posters made by members of the club.
9.	Science Play—"Applications of Science."
10.	Talk by local man interested in science or engaged in scientific work.
11.	Demonstration work for securing points.
12.	Motion picture on some selected science topic.
13.	Talk by the club sponsor on what science clubs in other schools are doing.
14.	Demonstration work for securing points.
15.	Science Play—"The Triumph of a Turnip."
16.	Stereopticon lecture on "Birds."
17.	Demonstration work for securing points.
18.	Devoted to the answering of questions proposed by the president at a previous meeting.
19.	Club banquet in the school cafeteria.
20.	Science Play—"Open Meeting of the Chemistry Club of Lorain High School."

7 Feldman, L. C. "Outside of Classroom Activities in Science." School Science and Mathematics, 20: 700-706, 1920.

8 Meister, Morris. "Managing a Science Club." School Science and Mathematics, 23: 205-218. General Science Quarterly. 7: 1, Nov. 1922.

21. Demonstration work for securing points.
22. Motion picture on some selected science topic.
23. Excursion to the telephone exchange.
24. Demonstration work for securing points.
25. Science Play—"Cinderella of the Metals."
26. Talk by local man interested in science or engaged in scientific work.
27. Assembly Program. This meeting of the club will be devoted to preparing for the program to be sponsored by the Science Club at the Assembly hour.
28. Demonstration work for securing points.
29. Science Spelling Match.
30. Science Play—"The New Assistant."

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Sanitary Etiquette

There are a large number of diseases known as contact infections, which are transmitted by personal contacts, which represent an exchange of bodily secretions or excretions between the persons involved. These contact are common under our modern complex social organizations. Some depend upon customs and usages difficult to break up, as, for example, inconsiderate use of the handkerchief with soiling of the hands, indiscriminate kissing, and hand-shaking. The Chinese custom of bowing and then shaking one's own hand is far more desirable from a sanitary standpoint. There are a number of these contacts, however, which cannot be defended on any grounds. They simply represent unhygienic manners.

The Mathematics Needed in High School Physics*

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The Problem

A review of some of the recent literature pertaining to high school physics shows that there is need for attention to some of the difficulties encountered in this subject.

Judd (4), for example, found that the percentage of pupils who elect science courses has steadily decreased, and that high school administrators say that such subjects are not as effectively taught as are the literary subjects.

Glenn (2) showed that physics teachers in over half of the fifty-nine Indiana high schools in his study regard their physics books too difficult for girls and one fourth regard them too difficult for boys. He found also that as many as 25% of the pupils who take this subject in some of the high schools fail to make a passing grade in it.

Randall, Chapman and Sutton (5) hold that pupils who have completed their high school physics course cannot solve ordinary physics problems satisfactorily.

Steele (7) found that 47% of the physics teachers in 155 Iowa high schools included in his study omitted half of the problems given by their textbook, and that approximately half of these teachers complained that their physics pupils used their algebra poorly. He found also that physics was required in 71% of the high schools included in his study.

In view of these findings, and others of a similar nature, this study was undertaken. Its chief purposes are:

1. To ascertain, by careful analysis, the mathematics needed to solve the problems in the five physics textbooks and laboratory manuals most frequently used in Iowa high schools in 1927-1928.
2. To construct an inventory test whose purposes are:
   (a) To be a means of testing the mathematical abilities needed to solve the problems in five high school physics textbooks and laboratory manuals.
   (b) To point out to mathematics teachers the items in their subjects which are useful in high school physics, and to serve as a guide in their remedial work.

* The author is indebted to School Science and Mathematics for permission to repeat any or all of his previous article which appeared in School Science and Mathematics in April, 1929. He is also indebted to Doctor Thomas J. Kirby of the University of Iowa for guidance throughout the study.

(c) To be a means of guidance. (To be given to the pupil before he makes a definite choice of high school physics as a subject for the following semester.)
(d) To be the basis for remedial work on the part of the physics teacher. (May be given early in first week of physics course, and may then be followed by a few days of intensive remedial work.)

SOME PREVIOUS STUDIES

Studies by Glenn (2), by Randall, Chapman and Sutton (5), and by Steele (7) were referred to very briefly under the discussion of "The Problem." A few other significant studies will now be reviewed:

Burgess (1) constructed a battery of tests to secure objective measures of various abilities in high school physics. Part III involves "problems which in the collective experience of a group of teachers usually give difficulty to beginning students." He found the following factors, ranked in order of importance (most important first) to be contributory to physics ability:

(a) Interest in physics.
(b) Simple mathematics of physics.
(c) Observation aptitude.
(d) Reading comprehension.
(e) Number series and logic.

Gribble (3) attempted to find the relationship between success in physics, as ordinarily taught, and

(a) Reading ability.
(b) General intelligence.
(c) Certain mathematical abilities.

Although Gribble used only ninety pupils, he presents the following tentative conclusions:

(a) The correlation between reading ability and success in physics is low but positive.
(b) The correlation between general intelligence and success in physics is low but positive.
(c) The correlation between certain mathematical abilities and success in physics is higher than either of the foregoing correlations.

Reagan (6) made a careful analysis of Millikan and Gale's *A First Course in Physics* in order to ascertain the mathematical needs of high school pupils who use that text. He classified his results somewhat arbitrarily under the headings of arithmetic, algebra, and geometry, but failed to construct a test to be used.

PROCEDURE

(A) Selection of the Textbooks Analyzed

In September 1928 a questionnaire was sent to a random sampling of 500 of the 946 public high schools in Iowa in

order to find out which five high school physics textbooks were most frequently used in that state. On the basis of replies received from 345 of these schools, the textbooks, in the order of frequency of use, were (most frequently used is given first):

1. Fuller, Brownlee and Baker.
2. Millikan and Gale (including Pyle's revision).
3. Carhart and Chute.
4. Black and Davis.
5. Dull.
6. A few scattered textbooks, such as Hoadley or Reed and Henderson, none of which was used in 2% of the schools.

(B) Technique in Analysis

The problems in the five most frequently used textbooks and laboratory manuals were first classified as mathematical-type and theory-type problems. By a mathematical-type problem is meant one whose solution involves quantitative treatment, whereas a theory-type problem is one whose solution does not require quantitative treatment. The former may be illustrated by: "Reduce 10 centimeters to inches," and the latter by: "Why can an athlete jump further in a running broad jump than in a standing broad jump?"

Table 1 shows the types of problems in the five physics textbooks analyzed:

TABLE 1

Types of Problems in the Five Leading Physics Textbooks

TEXTBOOKS	Theory Type		Math. Type		Total
	Number	%	Number	%	
Black and Davis	444	43.2	584	56.8	1028
Carhart and Chute	193	43.7	249	56.3	442
Dull	323	61.4	203	38.6	526
Fuller, Brownlee and Baker	1322	77.3	389	22.7	1711
Millikan and Gale (and Pyle)	375	58.4	267	41.6	642
Totals	2657	61.1	1692	38.9	4349
Average	531.4	56.8	338.4	43.2	869.8

All the mathematical-type problems in the three most frequently-used textbooks listed above were very carefully solved by every method that seemed reasonable to the author. Each problem was then recorded on the tabulation sheets. After having completed a careful analysis of the problems in the first three textbooks, the author solved the problems in Black and Davis and in Dull, but the processes involved were recorded on the tabulation sheets only in case the same process had not already been recorded for a problem in one of the

first three textbooks. In only a very small number of cases did the last two books involve a mathematical process not already recorded for one or more of the first three books analyzed.

Laboratory manuals were next examined, and the problems were solved, but the processes involved were not recorded on the tabulation sheets unless the same process was not already recorded for a problem in some textbook.

(C) Construction of the Test

After the analysis was completed, a tentative edition of an inventory test was constructed. In order to make the test of such length in its final form that it could be completed by the pupils in a laboratory period of eighty minutes or in two forty-minute periods, it was necessary to omit a very small number of items resulting from the analysis. It was therefore decided arbitrarily to omit any item which occurred in only one book and its manual unless it occurred at least ten times in that book and manual. It was also decided to omit any item which did not occur at least a total of three times in two or three books combined. It is held by the author that the omission of such items is not a serious handicap, since the great majority of the pupils will not come into contact with such items at all, and those pupils who do need those items may reasonably be expected to get help from their physics teacher when necessary, since there will be very few such occasions.

The tentative edition of the test has two forms, each of which requires approximately fifty minutes for completion. Part I of the tentative edition has seventy-one items, and these are usually classified, more or less arbitrarily, as arithmetic, algebra, and trigonometry. Part II of the tentative edition consists of twenty-one questions, and is concerned with items usually classified as plane geometry, although some of the items might well be otherwise classified.

Both parts of the tentative edition of the test were given to 265 pupils in nine high schools. None of these pupils had taken physics, but all of them could elect this subject at the beginning of the following semester or year.

On the basis of the results obtained by scoring the test papers of these 265 pupils, a revised edition of the test was constructed. A few of the items that occurred in the tenta-

tive edition of the test were not included in the revised edition for the following reasons:

(a) Some items were covered by other items in the test.
(b) Some items lacked objectivity.
(c) Since it was necessary to reduce the length of the test so that it could be completed in eighty minutes, a few items that appeared only a very small number of times were omitted.

A few alterations were made in the interest of clearness and objectivity. A few items were shifted from Part I to Part II in order to shorten Part I somewhat and lengthen Part II somewhat, so that each part can be taken in forty minutes.

In constructing the revised edition of the test, the first item in each part is the one that secured the greatest percentage of correct responses when given to the 265 pupils who took the tentative edition of the test. The last item in each part secured the smallest percentage of correct responses. The easiest items were placed first in order to encourage all pupils to continue with the test, and to prevent their "hanging up" on an item in the early part of the test.

Both parts of the revised edition of the test were given to 262 pupils in six high schools. None of these pupils had taken physics, but all were eligible to take it by the beginning of the following semester. None of these pupils had taken the tentative edition of the test.

Part I of the revised edition contains sixty-six items usually regarded as belonging to arithmetic and algebra. Part II contains twenty-four items usually regarded as belonging to plane geometry and trigonometry. Each part of the test can be taken in approximately forty minutes, and the entire test can be taken in a laboratory period of eighty minutes. A copy of the test, together with directions and tentative norms, may be obtained from the publisher, The Public School Publishing Company, Bloomington, Illinois.

Tables 2 and 3 show the percentage of correct responses made by the 262 pupils in six high schools included in the revised edition of the test. It will be noted that the items in the revised edition are not arranged exactly in the order of percentage of correct responses made by the 262 pupils. Among the reasons for a shifting in the position of some of these items are the following:

(a) Some items were altered somewhat in wording before being placed in the revised edition.

(b) The mere fact that an item is in a different position in the revised edition from what it was in the tentative edition, may have had some effect upon the percentage of correct responses.
(c) Problems in addition were written in horizontal form in one edition and in vertical form in the other edition.
(d) And perhaps most important among the reasons, there is a big difference in the preparation of pupils as well as of schools on various items.

TABLE 2

Percentage of Correct Responses
Part I, Revised Edition
(262 Pupils in Six Schools)

Items	Per Cent Correct	Items	Per Cent Correct	Items	Per Cent Correct
1	85.1	23	78.6	45	51.1
2	80.5	24	80.5	46	28.6
3	88.9	25	77.5	47	38.5
4	92.3	26	76.0	48	33.6
5	94.7	27	69.5	49	31.3
6	96.9	28	86.7	50	23.3
7	90.5	29	89.3	51	28.6
8	93.9	30	77.1	52	34.7
9	86.6	31	71.4	53	35.2
10	93.5	32	64.9	54	38.6
11	83.6	33	68.3	55	22.9
12	91.2	34	66.0	56	10.3
13	90.5	35	51.1	57	8.4
14	83.6	36	45.8	58	10.7
15	72.1	37	61.1	59	12.2
16	74.0	38	58.0	60	9.0
17	81.3	39	54.2	61	10.3
18	77.5	40	52.3	62	7.6
19	74.4	41	61.5	63	7.3
20	71.8	42	52.3	64	10.3
21	76.0	43	42.7	65	10.3
22	82.8	44	39.7	66	16.4
				Average	56.6

TABLE 3

Percentage of Correct Responses
Part II, Revised Edition
(262 Pupils in Six Schools)

Items	Per Cent Correct	Items	Per Cent Correct	Items	Per Cent Correct
1	97.7	9	82.1	17	37.4
2	93.9	10	57.2	18	72.1
3	90.9	11	84.0	19	50.0
4	82.8	12	61.8	20	43.1
5	79.8	13	89.3	21	64.5
6	74.8	14	56.0	22	49.2
7	77.9	15	58.0	23	49.2
8	85.1	16	50.8	24	21.0
				Average	67.4

Only four of the sixty-six items of Part I shifted their location over ten places, and the average number of places shifted in Part I is four places. Only five items in Part II shifted their location more than five places, and the average is three places. A shifting of as many of five or ten places will perhaps not affect the value of the test seriously. The pupils of some schools will always vary widely from the normal percentages of correct responses given to a certain item.

STATISTICAL CONSIDERATIONS

Table 4 gives the frequency distribution of raw scores made by 262 pupils on Parts I and II of the revised edition combined. Table 5 gives the percentiles for Part I, for Part II, and for Parts I and II combined. It should be noted that adding the score for a given percentile for Parts I and II does not give the percentile recorded for Parts I and II combined. This is due to the fact that intervals of three were used for Part I, whereas intervals of one were used for Part II, and intervals of five were used for Parts I and II combined. The variation is in no case greater than two points, however.

In order to obtain the reliability of the test as a whole, a sampling of 200 papers covering the revised edition was used. The raw score of each of the 200 pupils was found on the odds, and then on the evens for each part of the test, and for the test as a whole. The scores on odd items were then correlated with the scores on even items of the test as a whole. This gave the correlation of half of the test versus half of the test. The Spearman-Brown formula was then applied, and the reliability of the test as a whole was found to be $.904 \pm .008$

The probable error of a raw score was found to be 1.4317. If this probable error were increased to 2.00, and if a pupil's raw score on the test as a whole were 70, the chances are 1 to 1 that the true score would lie between 68 and 72, and the chances are 1310 to 1 that the true score would lie between 60 and 80.

TABLE 4

Frequency Distribution of Raw Scores
Parts I and II Combined
Revised Edition

Interval	Number of Pupils Getting this Score
88-92	1
83-87	3
78-82	4
73-77	13
68-72	20
63-67	22
58-62	36
53-57	35
48-52	38
43-47	39
38-42	24
33-37	11
28-32	10
23-27	6
18-22	0
Total No. of Pupils	262
Mean Score	53.45
Median Score	52.93
Range of Scores	23-88
Highest Possible Score	90

TABLE 5

Percentiles for the Revised Edition
Part I, Part II, and Parts I and II Combined

Percentiles	Part I	Part II	Parts I and II Combined
90th	50.0	22.0	71.0
80th	46.0	21.0	65.0
75th	44.0	20.0	62.0
70th	43.0	19.0	60.0
60th	40.0	18.0	57.0
50th	37.0	17.0	53.0
40th	35.0	15.0	49.0
30th	31.0	14.0	46.0
25th	30.0	13.0	44.0
20th	30.0	12.0	43.0
10th	26.0	9.0	37.0

CONCLUSIONS

The following conclusions are indicated by this study:

1. The five physics textbooks most frequently used during 1927-1928 in the 345 high schools included in this study, are, in descending order of frequency of use: Fuller, Brownlee and Baker; Millikan and Gale (and Pyle); Carhart and Chute; Black and Davis; and Dull.
2. Physics was required in approximately 70% of the 345 Iowa high schools included in this study, and it is taught in grade twelve, only, in approximately 84% of these schools.
3. The mathematics needed in solving the problems of high school physics involves a considerable body of information usually taught in artithmetic, algebra and plane geometry. Not much trigonometry is needed.
4. Most of the mathematics needed to solve high school physics problems is not very difficult.
5. Most pupils who are eligible to take physics use their mathematics poorly. The median score on this test is only slightly above half of a perfect score on the test as a whole.
6. There is definite need for maintenance drills covering the mathematical items and processes needed in high school physics. A work-book providing adequate drill on these items and processes would be valuable.
7. In some cases the pupils respond very differently if items are written in vertical form instead of in horizontal form. Sometimes the advantage lies with the vertical form, and at other times with the horizontal form. In view of this fact, both forms should be included in the test.
8. There is considerable difference in the preparation of different pupils on certain items and processes. The difference in preparation of different schools is also significant.
9. Very few of the pupils who are eligible to take high school physics know how to find the reciprocal of a number or the sine of an angle. One of two courses might therefore be followed: (1) teachers of mathematics should teach these items well, and should give sufficient drill for maintenance, or (2) teachers of physics should

be advised that they themselves should teach these items. At any rate, a pre-test by the physics teacher is advisable.

10. The mathematics department should make sure that its pupils are well prepared on the items of this test before the pupils elect physics.
11. It seems advisable to give this test, or at least a similar test, at the beginning of the physics course. It will show whether the pupil is weak or strong in the mathematics needed in high school physics, and will indicate certain lines of attack.
12. It is probable that this test will have considerable value for prognosis, but proof of this assumption awaits further experimentation.
13. This test is not sufficiently reliable for a single pupil on a certain item, but it is fairly reliable for the class as a whole on a certain item. A comparable form of the test should be constructed. A more reliable measure would be secured by giving both forms of the test.
14. The percentiles set up may be used as tentative norms. A greater number of cases is necessary in order to make the norms more trustworthy.
15. It would be worth while to study the types of errors made by the pupils. This awaits further study.

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EDITOR'S NOTE—A fuller discussion of this study is found in the author's doctor's thesis, which is on file in the library of the College of Education of the State University of Iowa, at Iowa City. Those who care to examine or use the test may obtain it from The Public School Publishing Company, Bloomington, Illinois.

Biology in Rural High Schools Correlated with Farm, Home and Community[1]

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Factors in the Selection and Arrangement of the Material in the Biology Course.

The most important factors involved in the selection and arrangement of the problems and topics to be studied in the course in biology in a rural high school are (in the order of their importance), the seasonal sequence, the occupational correlation, the home projects of the pupils who are in vocational courses, and the personal interests or hobbies of the pupils enrolled. Individual assignments are, of course, influenced by the same factors in reverse order.

Other factors are briefly discussed in the following paragraphs, but it will be observed that little emphasis is laid upon them.

I. THE SEASONAL FACTOR.

It is hardly sufficient to tell the teacher that the seasonal demands should govern his outline. The following suggestions may be found helpful.

1. The greatest wealth of biological material and the greatest number of stimulating problems are spread before us in midsummer. In these paragraphs we will ignore the fact that in some schools the instructor is given an opportunity to teach in midsummer. His task is easier and the summer teaching is considered in a separate section of the report.

2. In early fall, a few of the summer opportunities remain for a while, but strictly fall problems crowd for attention. Good flowers for study are soon gone, the leaves fall and animal life soon prepares to hibernate.

3. Plant life scarcely gets a start in the spring before some agricultural pupils leave for project work. Even the other pupils who remain until mid-June see only two months of real active plant life outdoors before school closes, and newly-planted gardens scarcely pass the seedling stage.

1 Continued from page 227, issue of May, 1929.

4. While a few such problems as ventilation and other home sanitation become important in the winter, much plant and animal life is dormant and there is time to do work which is crowded out of fall and spring, if it can be done naturally. This leads to the considerations which follow.

The *early fall lessons* should cover as large a range of plant life and animal life problems as possible before the frosts destroy the wealth of summer material. This wide range serves to introduce pupils to new material, to give the teacher a basis for estimating the previous experiences of the pupils, but more particularly to make the best possible use of perishable material which will not be available again in living form during the school year. Flowers best suited to class work cease to be abundant in September. It is also true that the vocational pupils will have a variety of agricultural experiences with which to correlate.

The *late fall lessons* still find ample plant and animal material approaching the dormant stage, which tends to increase the amount of collecting of materials to be used in winter. In fact, any soil for plant food studies and most seeds and dry fruits must be collected before the snow covers them.

The real *winter months* often begin about December 1st in portions of Massachusetts. No active outdoor life can be promised before April. It is more difficult to make frequent trips outside. This provides an opportunity to focus on human physiology and hygiene, home sanitation, food requirements of human and other animals, and many home-making correlations. Dairy cattle and poultry in winter quarters furnish many serious problems. Enough plants grown under glass can be provided to work out problems in photosynthesis, osmosis, etc.

Soils collected in the fall are ready for laboratory use in winter; seed study and germination tests must come before planting. Other similar possibilities obviously fall in the late winter.

The *spring lessons* are of three types: (a) the continuation of work started in the winter, such as the germination and seedling work; (b) the strictly seasonal practices, like grafting or observation of bursting buds, insect cycles, bird migrations, etc.; (c) preparation for continued observation and study on the part of the pupil during the summer. The last named has a great wealth of unutilized possibilities deserving further study and experimentation on the part of ambitious teachers.

II. The occupational factor.

For vocational pupils, current project study is nearly parallel to the occupational experiences of adults in the same vocation. (In agriculture and home-making this is frequently determined by the seasonal factor.) Home-making girls study and practice canning and preserving in the early fall, when the housekeeper is utilizing the surplus of fruits and vegetables. The agricultural boys study and participate in such practices as silo filling, pruning and harvesting when the local farmers are just beginning such operations. Thus the correlation with vocational teaching is determined in a large measure by local occupational practices.

Even in communities where there is no vocational course, most of the rural boys and girls in a high school are required to participate in many of these occupations and thus have a motivating experience with which the biology course should correlate.

The teacher should make a canvass or a survey of the occupational experiences of his district preliminary to making the course outlines. In the agricultural field this will require a seasonal list of jobs in gardening, poultry raising, dairy farming, fruit growing, etc. The teacher of agriculture usually encounters every day several important biological problems which he might refer to the teacher of biology, who should also have access to the agricultural course outline.

III. The home project as a factor.

For any pupils in vocational agriculture or home-making who have home projects under way, the problems which arise in connection with project work are frequently imperative. While they are often identical with the seasonal and occupational problems previously considered, they present the exceptional motivation of necessity.

A financial loss, the ruin of a crop the death of some of the poultry, or similar failure may face the pupil, and he simply must solve the problem. Insofar as this involves scientific principles it would obviously be unwise for a teacher to pass by such an opportunity. The project motive ought frequently to be the most important factor in determining the order of arrangement in course outlining. It will require emergency

changes in the course also. In the vocational schools it should predominate. Other pupils benefit in a high degree from the objective reality in such a home project emergency.

IV. THE PERSONAL INTEREST FACTOR.

Every boy is interested in certain problems more than others, and in many cases he has definite hobbies which may be capitalized in motivating his school work in biology. This will affect the course-making in several ways. Topics or problems in which a considerable number of pupils have a personal interest should be given added consideration in selecting topics. Individual problems for optional study provide for diversified assignments. Hobbies such as the collection of flowers or insects may be used as a thread upon which to hang related work and especially to extend the voluntary study through the summer weeks. This definitely affects the selection and arrangement of lessons.

V. THE NEWS FACTOR.

Local events, state-wide campaigns, scientific announcements, etc. help to furnish a "mind-set" of importance. Except for campaigns which are staged annually, it is not possible to forecast the very important news items which thrust upon public attention matters in the biological field. To utilize to a reasonable degree the interest involved in such events is an art. It requires the rearrangement of certain parts of a course or the substitution of an item out of the intended order. An overcrowded course of study does not lend itself readily to the utilization of these current items and therefore this must be borne in mind in making the course outline. It is easier to supplement a light program than to cut a heavy one.

The daily newspaper always contains some notable event involving biological problems or information. The chief difficulty is to seize upon only those which have sufficient value as compared with our routine plans.

VI. THE TEXTBOOK AS A FACTOR.

There are two types of textbooks in biology which use the problem method of development. The following are examples of each.

"NEW CIVIC BIOLOGY," George W. Hunter, New York, American Book Co., Revision of 1926. With most of its problems selected on a civic basis. The "Laboratory Problems in Civic Biology," to accompany this text, is entirely on the problem basis.

"CIVIC AND ECONOMIC BIOLOGY," William H. Atwood, Philadelphia, P. Blakiston's Son & Co., 1922. Uses problems of relationships, responses, functions, etc., in plant and animal life. The laboratory manual to accompany this book is entitled, "Problems, Projects and Experiments," by the same author and publisher.

There are arguments in favor of each type. Each needs supplementary reference reading material. Other such texts are referred to in the classified lists given elsewhere in this report. Many schools are already supplied with textbooks of the *informational type*, (not on a problem basis), which should be used entirely on the reference book plan by laying out problems in advance of the assignment in the text. Several "General Science" texts prepared on the "problem" basis are fully *fifty percent biology in subject matter.*

The chief precaution in using any type of text in this course is the avoidance of following the order of the text. Lay out the course independent of the text at the outset. There are many arguments in favor of a common reference text in the hands of each pupil, if rightly used. The teacher with limited time and large classes must have something of the sort and few schools have adequate and sufficiently varied reference facilities.

VII. THE "FUNDAMENTAL PRINCIPLE" AS A FACTOR.

While it is admitted to be true that no pupil should finish the course in biology without comprehending certain fundamental principles, it is advised that these generalizations should be arrived at as a part of the solution of problems. This will reverse the common and unwise practice of learning the principles first to be followed by experiments in the same field. The teacher needs to be cautioned to check the course outline to make sure that each principle of importance will be met in the solution of problems. However, in terms of this course no principle is "fundamental" unless it is indispensable to the work.

The principle of the cross pollination of flowers and certain basic principles of heredity confront the pupil in the problems of improving a variety or strain of vegetables or fruits and therefore they are "fundamental." The statements or theories of Lamark and DeVries regarding the inheritance of acquired characteristics are yet in dispute, lack the conditions to be "fundamental" in this course and should usually be reserved

for the individual assignments of pupils whose special interests may be involved in such study.

Any further reference to this factor which seems necessary will be brought out in the discussion of *methods*. To the same section will be reserved the discussion of the means for carrying through the year certain *"master problems"* so as to save the course from the "hash" or thoroughly disorganized pot-pourri it might easily become.

VIII. SYSTEMATIC CLASSIFICATION AS A FACTOR.

Contrary to an earlier usage, systematic zoology or systematic botany should not be the goal in this course. There are occasions when the relationship of plants becomes a tool or a key item in solving an important problem. The identification of certain plants or insects is occasionally necessary. Lessons upon identification should be so selected and arranged as to make the usefulness of this obvious to the pupils. Identification contests should be considered as serving several purposes in the course, but never should be an end.

TEACHING HELPS. METHOD IN BIOLOGY.

I. THE APPROACH TO A PROBLEM.

(The technique of arranging problems follows in Section II.)

1. *Always seek the most natural way* for the pupil to encounter the problem. The fact that he meets this problem as a challenge increases the motivation in solving it. If it is staged as a baited trap he is less likely to respond. The following are actual teaching cases which will illustrate this point.

a. Pupils in selecting seed corn have encountered both mixed ears and sterile ears, not "filled out." The teacher had expected this would occur during the month and had planned a procedure involving problems in "The necessity of pollination"; "The essential parts of a perfect flower"; "Parentage of pure-bred seed." This particular encounter raised problems related to the first two topics and motivated the study.

b. In apple packing time, Mr. S. found enough wormy apples to go around his class and treated the pupils. The problem discovered itself and started an interesting cycle of topics, beginning with the codling moth.

c. A pupil brought a dead pullet to Mr. N., and asked what was the cause. Mr. N. surmised a digestive disorder, and changed the order of his course arrangement to use this opportunity.

He secured a normal fowl, which was opened for comparison. The normal digestive system was studied with care and the abnormal organs inspected. This initiated a thorough study of normal digestion in addition to the solution of this particular problem.

d. A class set cabbages in the field under the direction of Mr. R., and later found several cabbages flat. This must be stopped, as it means serious loss. What is the cause? How can the pest be controlled? It proves that some of the pupils have in a formal way read something about the cabbage maggot before, but it meant nothing. Now they identify the pest, find a few suggested methods of control and decide on the best for this occasion. They have difficulty in buying "corrosive-sublimate," because it is a dangerous poison. They have to learn the cautions and why. They apply the remedy, leaving a ten-foot row as a check, saving the crop yet losing all but one of the untreated plants.

The preceding are examples of natural approach of which *b* was staged, *a* and *d* were anticipated by the instructor accurately as to time, while *c* required a rearrangement of order of his course as planned.

2. *Have pupils suggest methods* of trying to solve the problem. This does not remove the necessity of the teacher having a carefully planned method of procedure. It does make power in working out a solution to new problems as he meets them. This is more important to him than the solution of this particular problem can be.

Check over the suggestions with the pupil and the class, discuss the steps, rearrange them and arrive at an attack either in accordance with your plan or different. Lesson plans are made to be improved, but "no plan" leaves the teacher without a basis for measuring his improvement. Note these improvements on your plan for the future.

A single example will illustrate the pupil participation in planning a solution of a problem. This actually occurred in one of our schools.

The class had used the starch test and already found stored starch in roots, tubers, and stems. The reading had stated that starch is made only in the green parts of the plant (the leaves primarily) and only in the presence of sunlight.

The problem has been raised: "How can we demonstrate that starch is in the leaf only after the action of sunlight?"

Teacher. "How do you suggest we should begin to solve this?"

Pupil 1. "We should keep some plants in the sun all day and keep one in a dark closet."

Pupil 2. "We might cover parts of some leaves to keep out the sun."

Pupil 3. "We should find how long the starch remains in the leaf after the sun is gone."

Pupil 4. "We ought to get rid of the green in the leaf to know when we have a real starch test."

Teacher. "How can we do that without changing the starch?"

Pupil 4. "Guess I should have to look that up."

Teacher. "All of you should do that much in advance. Who will take charge of preparing the dark closet specimen?"

Pupil 1 *and Pupil* 4. "We will, but we want two plants of the same kind, one for the sunlight as a check."

Pupil 5. "Should we find whether a cloudy day gives any result?"

Teacher. "You try it the first opportunity. Who wishes to try darkening parts of the leaves as one method?"

Pupil 2. "That was mine. John and I will start that today, to be tested tomorrow."

Teacher. "Then we have agreed to look up the way to remove the green in the leaf. Find all you can about this green material. What is it? Can it be removed and used for any purpose? Is there anything in animals which corresponds to it?"

"Each of you has a preliminary job, so we will be prepared to make tests tomorrow and I will have the necessary reagents and apparatus. We will do it as thoroughly as we are able. Go now to your preliminary preparations and then to your reference study. Take only those notes which you think you will need later."

The problem cited deserves all the time necessary to succeed since much later reading involving the principle of photosynthesis will have a reality to these pupils. With close attention by the teacher this laboratory work can be as efficient as a demonstration yet leave the pupils with the sense of "confidence from having done."

Skill in teaching manifests itself in bringing about such situations and guiding the pupils instead of telling them. The laboratory approach is usually better pedagogy than the laboratory "follow up" of study.

3. *Foresight in planning long in advance* is necessary to prevent perfunctory teaching. The exact procedure in a class should not be detailed long in advance but there are certain preliminaries which require time.

This preparation often includes the collection of data, the location of contrasting material, etc., and in most cases the pupils will benefit as much by participating in these preliminaries as in the subsequent work. A few examples will suffice to illustrate this.

Seeds gathered in sufficient quantity in the fall will serve for seed studies, germination tests and similar work in the winter. Soil samples gathered from project fields in the fall and properly labelled will serve in the winter better than soils from no particular place.

Observations of birds, insects, flowers or trees need to begin some time before the record is to be used for advanced study.

One class began the study of trees by starting a tree map of a certain section of the town. The new trees were encountered gradually, the identifying parts brought to class and a study made of type, values, type of wood or lumber as well as identifying characteristics. The lessons on botanical relationships came some time after the collection of data started.

II. SEQUENCE IN STUDY AND PROJECTS.

1. Seasonal occurrences tend to build up a *spiral system* of studying biology because most biological ideas and principles are not isolated. It is equally true that very persistent interests, amounting to hobbies for some pupils, render it desirable to revive many principles through new approaches and associations. Not all of this will require class work, though it is well to have each pupil report his "project" occasionally to the class.

There are some important phases of biology that are much better taught by recurrence than by consecutive periods of more intensive study. Well-known pedagogical principles, as well as the seasonal opportunity to make first-hand study, support this idea. Two illustrations out of many will be cited to confirm this.

Lower Forms of Plant Life. (Suggestive)

a. Control of food spoilage.—September.
b. Canning fruits and vegetables. Sterilization.—September.
c. Silo filling. Desired fermentation.—September.
d. Diseased apples, etc. Fungus.—October.
e. Smut on corn. Other smuts and rusts.—Fall.
f. Clean milk. Bacterial side.—Any time, but fits vocational study in early winter.
g. Contagious diseases.—Whenever fitting.
h. Special sanitation of poultry.—Winter.
i. Treatment of seeds to control disease.—Early spring.
j. Control of flies. (Bacterial).—Spring.
k. Bordeaux and other fungicides for summer practice.—Late spring.

Heredity.

a. Mixed seeds in harvest.—September.
b. Nature's plan of cross pollination.—September.
c. Selected breeding pen of poultry.—December.
d. Selecting seed for the crop.—March.
e. Genus, variety and hybrid in plant groups.—Spring.
f. Plans to improve strain in flock or crop.—Spring.

2. *Keeping the series elastic* may best be accomplished by either cards or a loose-leaf arrangement which permits frequent

rearrangement. Some teachers have used both a 3x5 card for a descriptive title and a loose-leaf lesson plan to correspond. The less complicated the system the more probable its real usefulness.

The cards have the advantage of ease in rearrangement and the size 4x6 inches also permits helpful notations on materials or outline (but not a complete teaching procedure).

The cards or lesson outlines should be shifted until the appropriate arrangement seems settled. Then mark in pencil

F—7B.

PROBLEM:—

What botanical relationships exist between any of our crop plants?
Are any of the weeds related to any crops?
Method: 1, Examine. 2, Check in text. 3, Tabulate.
Examples:—

The Cruciferae—Mustard Family.

Crops	*Weeds*
Turnip	Wild Mustard
Radish	Shepherd's Purse
Cabbage	Peppergrass
etc.	etc.

Solanaceae—Nightshade Family.

Potato Tomato	Horse Nettle
Eggplant	Bittersweet
Jerusalem Cherry	Nightshade
etc.	etc.

Umbelliferae—Parsley Family.

Carrot	Queen Anne's Lace
Parsnip	"Poison Hemlock"
Parsley, etc.	

on an upper corner of the card the month and number of lesson, as "Oct. 10." Record successive experiments with new dates but without erasures, as this will help in later comparisons. Instead of months, seasonal abbreviations may be used, as F for fall, L. W. for late winter.

Also mark each card in pencil with an abbreviation and number indicating the field of science corresponding to a simple key selected by the teacher. To illustrate: B-6 might indicate the sixth lesson in the field of botany; Z-3, the third in zoology; H-5, the fifth in hygiene; E-9, the ninth in entomology or insect life. This cannot be standardized to advantage.

The advantage of using the cards lies chiefly in the ease with which the order may be changed, including the elimination of one or the addition of another. If the size is not over 4x6 inches there is little danger of working out a complete teaching outline which would tend to fix the treatment, which ought to be frequently improved.

There is also an opportunity to insert cards of other colors to indicate unusual correlations or special problems which may not be regularly required. These colored cards have been used by some teachers to indicate special phases, such as blue for human hygiene and sanitation, buff for home-making problems, red for insect and disease control. The chief value lies in the adaptability of the device.

A few samples are given to indicate how some teachers have used this scheme. These 4x6 cards were used in connection with the course outlines on pages 218 to 227 of this report. These teachers used in some cases brief suggestions of procedure, and in other cases typical items which might appear on the blackboard as data accumulated in the class.

F—22—B.

PROBLEM :—
What is the botanical type of fruit in each kind we use as food?

Method: 1, Bring in the fruits. Examine each. 2, Judge. Verify in text. 3, Record. 4, Tabulate. 5, Seek. Begin with fruit and attach name after study.

Common fruits, as apple, peach, pear, orange, "berries," tomato, bean, etc. Also compare with weeds and unusual fruits.

Use the terms pome, drupe, pepo, or berry accurately, but do not make definitions the chief aim.

Extend to cover all the fruits which are named.

L. F.—4—B.

PROBLEM :—

1. What organs of the plants do we eat in the case of each garden vegetable as usually served? 2. What methods are used to improve each as to size or quality?

Method: 1. Examination. 2. Recording judgment. 3. Reports and discussion. 4. Verification by authorities. 5. Tabulate. Use as wide a range of varieties as possible.

Vegetables suggested:

Roots eaten: Turnip, beet, carrot, etc.
Underground stems eaten: Potato tuber.
Bulbs eaten: onions.
Normal stems eaten: asparagus.
Abnormal stems eaten: kohl rabi.
Buds eaten: cabbage, brussels sprouts.
Leaf petioles eaten: celery, rhubarb.
Flower or flower buds eaten: cauliflower.
Leaves eaten: spinach, lettuce, endive.
Fruit: tomato, eggplant, string beans.
Seeds only eaten: peas, beans.

W—14—Food.

PROBLEM :—

Into what general groups may the essential parts of the food of human and other animals be arranged? How may we in a rough way detect and estimate the amount of each in any food?

Method: 1. Laboratory tests of pure starch, fat, sugar, albumen, etc., for elimination and check. 2. Follow by complex foods. 3. Group and verify.

Example: Test dilute cornstarch "solution" with iodine solution. Repeat for potato starch and other starches.

Check with albumen, fat and sugar. Test roots, tubers, seeds, etc., for starch.

Tabulate results and proceed to Fehling's test for grape sugar.

III. TEACHING PLANS AND LESSON OUTLINES.

With a faulty teaching plan it may be possible to do a poorer job at teaching than with no plan at all but it is not very likely that a teacher would spend even a few minutes in planning without avoiding some dangers. Properly developed plans will serve not only as a basis for improved procedure but will serve as a test for the success of teaching the lesson, if checked after the period closes. A few items applicable to biology teaching follow. (See sample plans in supplementary section.)

1. *A procedure plan* should be far superior to a *subject-matter outline*. The former will deal with the sequence of events in the class and will recognize fundamental teaching principles.

a. Each pupil should be active throughout the entire period and at something distinctly worth while. This will mean considerable "motor" activity as well as mental. It will accord with Kilpatrick's statement that "We do first and learn afterwards."

b. We shall discover the pupil's background of experience and from that move on to new discoveries. (Identification tests are examples.)

c. The early establishment of an objective will be followed at the close by clinching the real lesson learned.

d. The problem will be so devised by the teacher that (1) the pupil may be led to state it as his own problem (not passed out by the teacher), (2) the class may suggest some of the steps in the solution, and (3) when the study is over there will be a resultant "principle" at which the teacher aimed the study in advance.

e. One single problem or a very limited number of facts may be mastered by the class, whereas a larger number will result in confusion.

2. *The teacher should review his own mastery* of the subject-matter far beyond the known requirements of the day's work. He should not expect the class exercise to exhaust this, and he should not permit comparatively irrelevant tangents to lead him to display his knowledge.

For these reasons he should add to his procedure plan a brief list of the subject-matter items he will be justified in developing. To prepare a set of "seek further" questions which will be proposed for inquiry or study after the lesson may avoid the unwise overloading of the present lesson.

3. Under no consideration should a list of topics in the textbook be adopted as a substitute for a plan.

4. *The aim or objective of a lesson should be carefully scrutinized in advance.* This will avoid a poor procedure and may prevent failure in teaching. The following example will illustrate this:

"Photosynthesis" may be taught to a college class in biochemistry for the purpose of understanding the chemical reactions in the making of carbohydrates such as sugars and starches. The application outside of chemistry may be unimportant.

In biology for high school pupils the study of photosynthesis is for very definite applications to plant growth, and it is not important to learn the exact chemical reactions. These conclusions which we desire the pupils to reach might be stated as follows:—

a. The leaves manufacture the starch and plant tissue material.
b. The green chlorophyl is the essential compound in this process.
c. Sunlight is the force which must do the work.
d. Starch and sugar are derived from the CO_2 of the air and from water. No mineral is required for these.
e. Anything which destroys leaves (as insects), or destroys the green in the leaves (as disease), curtails starch making (as for potato tubers).

To replace these objectives by intricate biochemistry will insure failure.

5. *More remote objectives* must be kept in mind by the teacher but must not be substituted for the immediate objectives in lesson planning.

As an illustration, consider the objective of making the pupil more observing of the plant life about him on the farm. Until he has some experiences which make him realize the necessity of this, it is meaningless to him as an aim. If, however, we seek to find any weeds which seem related to the tomato and potato plants, the economic problem becomes an entering wedge to require more careful observation of flower, leaf and stem for one group of plants.

The converse might be true for the pupil who has a hobby of collecting plants but does not realize any economic significance in the relationships.

6. *Pupil's outlines* may be prepared in advance by the teacher, but *should rarely,* if ever, *be passed out at the beginning.* By skilful guidance on the part of the teacher, the pupils will propose many of the steps required in the new work. The more exact statement may then be interwoven by the teacher but the outline comes to them as partly their own plan of procedure. (See sample outlines.)

This caution is especially important for laboratory work or field trips wherein the usual "manual" violates the principles stated. The pupil as a rule has no part in planning but has the directions imposed upon him. Making the plan or outline and drawing conclusions to be verified later are the most important things for the pupil to do for himself.

IV. INDIVIDUAL PROGRESS AND SPECIAL ASSIGNMENTS.

Early in the course the instructor should check on his list of topics or problems those which he considers indispensable for each pupil. This minimum group should be carefully pruned. To it should be added a second group of problems nearly as important and very valuable for all pupils of average capacity. All pupils should be expected to cover the first or minimum group, and most pupils should carry each term the seasonal problems of the second group.

1. Each pupil should be encouraged to select certain fields of special interest and to work out problems which are related to his home projects or in the field of his special hobbies. The time he may devote to a hobby should be rigidly cut until he has covered at least the current assignments in the "minimum" group of topics and (for most pupils) the "normal" group.

For even the slowest pupil, reasonable substitutions in the field of his home project should be permitted, since they are "essential" and will probably motivate other study as well.

2. Daily class discussions will usually center about the common assignments, the minimum or normal groups of problems. However, in connection with these there may be special assignments upon which some pupil may make a report which will more completely explain some part of the work. While the class is briefly considering "Hybrids from cross pollination," some pupil will probably be able to report on "Mendel's experiments in plant breeding and the laws he discovered." The rest of the class will find this interesting but should not be held strictly to account in remembering it.

3. In the case of optional projects or problems covering a longer period and supplementing the normal group of assignments, it is not always desirable to require the reading of a summary report before the class.

Evidence of work done and results secured should be presented to the teacher, but the class should hear only those selected parts which are of peculiar interest or which bear upon the class problems. The other pupils should not be required to take notes on these reports nor to learn more than the particular items selected by the teacher and given special emphasis.

Some teachers have been quite successful in conducting one period a week for the special reports but there is a tendency to present abridged summaries which mean little to the other pupils. There is also a temptation for the teacher to put upon the pupils a requirement of remembering what has been reported. This is the lecture system at its worst.

4. The individual assignments on an optional basis will lead naturally to "summer observation projects." Since summer presents the greatest abundance of interesting plant and animal life any plan which will carry over through this season is of great value.

It should be largely voluntary, though a *deferred rank* in science may result in something worth while. One school has an exhibit in October and gives medals for the most meritorious summer science work.

While an occasional boy is willing to study and put much time on summer observations, most boys who work will consider this as drudgery, and this is opposed to the real objective of this plan. It will be found wise to appeal to the boy's interest, to plan for experiences which may not call for much extra time but may fit in with his regular work. His work may be more pleasant if he appreciates the birds, flowers and insect life which surround him.

This committee originally was a "Summer Science Committee," and an important section of the general report deals with the ways and means of securing ideal summer science observation and study on a basis most nearly voluntary.

Additional phases of methods are discussed briefly in connection with supplementary material and in the consideration of other phases of science. A few pages of supplementary material are distributed herewith and other sections will be distributed later.

SUPPLEMENTARY MATERIAL IN BIOLOGY.

Check List of Important Science Items.

Principles and Facts to be Mastered.

This list is *not in the order* in which such topics should be taught and *some* of them *may not deserve any attention in some courses.*

A. *Plant Biology or Botany.*
- *Plant Reproduction.*
  - Flowers—Pollination—Seeds.
  - Spores—Lower types.
- *Plant Propagation.*
  - Seeds and development. (Factors in germination.)
  - Monocotyledons and dicotyledons.
  - Grafting—Budding.
  - Slips, runners, layers.
  - Tubers—Bulbs.
- *Conditions Essential for Growth of Plant.*
  - Moisture, temperature, air, light, food.
  - Seed selection as related to improvement.
  - Breeding and crossbreeding. Mendel's law.
- *Nutrition of Plants.*
  - Organs, processes.
  - Photosynthesis.
  - Osmosis. Digestion.
- *Plant Structure.*
  - Cells and tissues.
  - Organs and functions.
  - Relations of roots, stems, leaves and flowers.
- *Plants in Relation to Man.*
  - Foods. (Clothing, medicine, shelter.)
  - Forests and conservation.
  - Fungi—bacteria—yeast—molds.
  - Weeds and other noxious plants.
- *Plant Classifications.* (Groups of importance.)
- Plants as forage for animals other than man.
- Soil requirements and fertility.

B. *Animal Biology or Zoology.*
- Improvement of animal breeds, etc. (Mendel's law applied.)
- Animal life in relation to man.
- Distribution of animal life.
- Relations of plants and animals.
- *Insects*—General characteristics.
  - Typical Life Histories.
    - Metamorphosis—Complete, Partial.
    - Natural classifications (also as to control).
  - Economic importance.
    - Fertilization of flowers.
    - Destruction of plants.
    - Methods of control.
    - Special pests of local importance.
  - *Bees*, special study.
    - Other valuable or helpful insects.
- *Birds.* (Include Poultry.)
  - Economic importance. Structure.
  - Life history and habits.
  - Records of migrations, etc.
  - Conservation of bird life.

Frogs and other Amphibians.
Life history. Economic importance.
Fishes.—Structure. Economic importance.
Lower animal forms (which are of local importance only).
Mammals—Farm animals.
General Classifications.
Comparative structure. Common functions.

C. *Human Biology.*
General Structure.
Organs and tissues.
Foods and their uses.
Processes of digestion and assimilation.
Sources of various nutrients.
Diet—balanced rations.
The hygiene of digestion.
Food preservation (correlate with bacteria).
Circulation of blood.
Organs and functions.
Processes involved.
Hygiene of circulation.
Respiration as related to circulation.
Organs and processes.
Hygiene of breathing. (Emergencies.)
Microorganisms and human health.
Diseases via food and digestive organs.
Diseases via respiration.
Diseases via wounds and bruises.
The senses.
Organs and structure. Hygiene, etc.
Processes of sensation.
Muscular development.
Functions. Hygiene.
Emergencies. First aid.
Drugs, narcotics, etc.
Home sanitation.
Community sanitation.
The war against—
Malaria, yellow fever, typhoid, tuberculosis.

BIOLOGY PROBLEMS

ORIGINATING IN OCCUPATIONS AND EXPERIENCES.

Correlation lists should be prepared by the Biology teacher, with the assistance of teachers or workers in other fields. As an example of the method of doing this the following is offered. More complete suggestions may be furnished with later supplements, but it must be remembered that the great value to the teacher and his class will come from the local needs which a personal investigation or survey discloses.

Lists of this nature should be drawn up in a seasonal arrangement to suggest the most timely correlations.

POULTRY GROWING.

Occupational Jobs.	Biology Correlations.
Selecting new birds.	Principles or selection, heredity and breeding.
Fattening culls.	Physiology of fat production.
Renovating laying house.	Parasites of fowls. Sanitation. Function of direct sunlight. Functions of ventilation.
Feeding the laying flock.	The nutrients. Body maintenance. Sources of vitamines. Calcium assimilation.
Etc.	Etc.

Foods Required by Plants.[2]

LABORATORY

THE STEM.

Step 1. Water Content.—Cut a piece of green wood to weigh 6 to 10 grams. Subject to moderate heat and reweigh. Continue this until the weight becomes constant. The loss of weight is the water content.

Step 2. Carbon Content.—Place the dehydrated wood in a retort and burn. Reweigh until the weight becomes constant. The loss of weight is the carbon content.

Step 3. The residue is the mineral content. Test for potassium.—Hold a crystal of potassium chlorate with the forceps in the non-luminous flame of a bunsen burner and observe through a blue glass. A violet color shows the presence of potassium. Dip a clean platinum wire into the residue dissolved in water and test in flame for potassium. Test for sodium.—Dip a clean platinum wire into a solution of common table salt. Hold in the flame of a bunsen burner. A bright yellow color imparted to the flame shows sodium. Try the same with a solution of the residue.

Step 4. Test fall wood and spring wood for starch and sugar content, using the iodine and Fehling tests.

Step 5. Place the cross-sections of young wood in iodine solution and in nitric acid. Where are the starch and protein in the stem?

THE LEAVES.

Step 6. Weigh some green leaves. Dry out with blotting papers and reweigh. The loss of water is the water content. Examine the dermis of a leaf and study the stomate which releases the water. Study the upper and lower dermis and compare the number of stomates in each. Which contains the more?

Step 7. Test leaves for starch. Keep a leaf in the dark and one in the light. Extract the chlorophyll for each with warm alcohol. Wash the leaves and test for starch with iodine. Which leaf was making starch?

Step 8. Weigh some dried leaves. Burn in a retort. The loss of weight is the carbon content. The residue is the mineral.

Step 9. Study the leaf in cross-section, noting the food-making and storage regions.

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2 This is a specimen lesson plan, covering several days' work, prepared and used by Miss Josephine Davis at the North High School, Worcester, in a class in science correlated with fruit-growing.

THE FRUIT.

Step 10. Weigh a piece of apple. Dehydrate it and reweigh. The loss in weight is the water content.

Step 11. Test the apple pulp for sugar, starch, and protein.

Step 12. Test the apple pulp for acidity.

QUESTIONS: (Introduced as needed. All reviewed at close.)

1. What food elements are desired by plants?
2. What elements are most common in the ground?
3. What elements have to be supplied the most often?
4. When is a complete fertilizer best? When a one-sided one?
5. Why is nitrogen needed? Why calcium? Why phosphorus? Why potash?
6. What part of the plant makes the starch?
7. Where do the materials come from to make the starch?
8. Why is starch converted into sugar before it is used by the plant?
9. What may the sugar be converted into on arriving at the growing region?
10. Where is most of the protein found in plants?
11. What part of the bast fibers carry the protein?
12. Where is the starch found in the plant?
13. How did the starch get into the wood?
14. When is wood richest in starch?
15. What happens to the starch as spring approaches?
16. What is the ratio between air-supplied and soil-supplied materials?
17. What is the value of so much water in plants?
18. Where is food stored in plants?
19. What foods are stored in plants?
20. What does the ash of plants tell you about the fertilizers to be used?
21. What does the percent of carbon in plants tell you about the necessity for good respiration?
22. What practice should be carried on in the orchard to give a good supply of air to the ground?
23. How does the plant rid itself of its waste?
24. What is the composition of fruit?
25. Which of the fruits in your locality are classed as acid?
26. Are citrus fruits acid? What acid is in them?
27. What minerals are found in fruits?
28. What percent of the fruit is water?
29. Give a list of starchy fruits, sweet fruits, those rich in minerals.
30. Where is food made in plants?
31. How is food made in plants?
32. What is the function of the stomata?
33. Why are they more numerous on the under surface of a leaf?

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Kahlenburg, Chemistry of Daily Life, pp. 244-254.
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Record Economic Woods, pp. 50-60.
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Freckles Frog: Stories for Little Folk

Ruth Elizabeth Clement, Worcester, Mass.

Part I. All About Freckles.

CHAPTER 1. HAPPY FRECKLES.

Freckles was the happiest frog in his puddle.

He dived all morning.

He swam all afternoon.

He sang all evening.

He had all the minnows, crayfish and tadpoles that he could eat.

Freckles was different from his cousins.

He was much more beautiful.

He had square yellow dots on his brown back.

That was why his name was "Freckles."

The dots were edged with dark brown.

And, best of all, his waistcoat was a pretty orange-yellow color.

Freckles' cousins all had plain blue-green coats and ordinary white waistcoats.

Freckles liked to bask in the sunshine and breathe the fresh air.

CHAPTER 2. FRECKLES' DOORYARD.

Freckles' puddle was near a trickling brook.

The brook flowed through a meadow.

Many flowers grew in the meadow.

There were sweet white violets and blue flags right in Freckles' front yard.

Freckles loved the springtime when the flowers blossomed.

He could go outdoors then and play.

During the winter Freckles had to make a little hole in the mud at the bottom of the brook.

He crept into the hole and slept all winter.

It is much too cold in winter for frogs to be out.

All of Freckles' cousins slept all winter also.

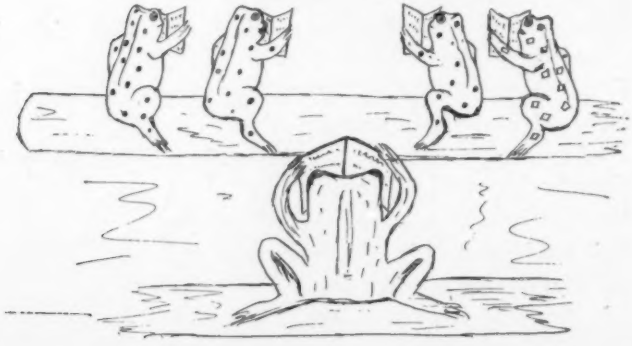
CHAPTER 3. READY FOR SCHOOL.

One spring morning Freckles was taking his daily plunge.

He was extra careful because school opened that day and he wanted to be very clean.

He sang this little song because he was so happy:

"Twenty froggies went to school
Down beside a rushy pool;
Twenty little coats of green,
Twenty vests all white and clean.
'We must be in time,' said they;
'First we study, then we play;
That is how we keep the rule
When we froggies go to school.'
Master Bullfrog, grave and stern,
Called the classes in their turn;
Taught them how to nobly strive;
Likewise how to leap and dive;
From his seat upon the log,
Showed them how to say "Kerchog!"
Also how to dodge a blow
From the sticks that bad boys throw.
Twenty froggies grew up fast;
Bullfrogs they became at last;
Not one dunce among the lot,
Not one lesson they forgot;
Polished in a high degree,
As a froggie ought to be,
Now they sit on other logs,
Teaching other little frogs." —*Anon.*



CHAPTER 4. WHAT FRECKLES LEARNED ABOUT HIMSELF.

At school Freckles studied the story of his life. This is what he learned:

In early spring I was a little egg
  In a big jelly mass with brook mud dim;
I hatched to a tadpole with never a leg,
  But with a long tail-fin so I could swim,
And with nice little gills on the side of my head
  Which after a while I thought best to hide;
Then I swallowed the water to breathe, instead,—
  It flowed out through a hole in my side.
I ate little things too small to see,
  I ate a great many and I grew with vim,
My hind legs came with webbed toes free
  And they soon learned to kick and help me to swim.
My tail shortened up and my eyes bulged out
  And my two legs in front began to grow.
Before anyone guessed what I was about,
  I was a nice little frog, you know.
My tongue is just like tangle-foot made;
  It is fastened to the front of my jaw;
When a beetle, a fly or a bug comes along
  I aim and sweep them into my maw.
I sleep in the mud the whole winter long.
  In the spring I come out and sing a sweet song.

—*Comstock.*

CHAPTER 5. THE MOCKING BIRD JOKE.

Freckles was clever.
One day he wrote a poem. The name of it was:
"A Legend of Lake Okeefinokee."
There once was a frog, and he lived in a bog,
On the banks of Lake Okeefinokee.
And the words of the song that he sang all day long
Were "Croakety, Croakety, Croaky."
Said the frog, "I have found
That my life's daily round
In this place is exceedingly poky,
So no longer I'll stop
But I swiftly will hop
Away from Lake Okeefinokee."
Now a bad mocking-bird, by mischance overheard
The words of the frog as he spokee.
And he said, "All my life Frog and I've been at strife,
As we lived by Lake Okeefinokee.
Now I see at a glance here's a capital chance
For to play him a practical jokee.
So I'll venture to say that he shall not to-day
Leave the banks of Lake Okeefinokee."
So this bad mocking-bird, without saying a word,
He flew to a tree that was oakey.
And loudly he sang, till the whole forest rang,
"'Oh! Croakety, croakety, croaky!"
As he warbled this song, Master Frog came along,
A-filling his pipe for to smokee,
And he said, "'Tis some frog has escaped from the bog
Of Okeefinokeefinokee.

I am filled with amaze to hear one of my race
A-warbling on top of an oaky.
But if frogs can climb trees, I may still find some ease
On the banks of Lake Okeefinokee."
So he climbed up the tree; but alas! down fell he!
And his lovely green neck it was brokee.
And the sad truth to say, never more did he stray
From the banks of Lake Okeefinokee.
And the bad mocking-bird said, "How very absurd
And delightful a practical jokee!"
But I'm happy to say, he was drowned the next day,
In the waters of Okeefinokee.

—*Anon.*

CHAPTER 6. FRECKLES GOES TO NORMAL.

Freckles' father and mother thought that he should go to normal school.

They hired old Leaping Bullfrog to carry Freckles to normal school.

Two of Freckles' friends went part of the way with him.

This is how they looked just before they left.

Leaping Bullfrog is a cousin of Freckles.

He is eight inches long.

In the southern countries his relatives are much larger.

Down there people eat frogs' legs; the meat tastes like chicken.

Leaping Bullfrog is glad he lives in the North.

Freckles is glad he is going to normal school.

CHAPTER 7. IN A NEW HOME.

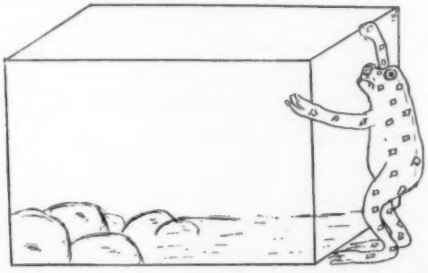
When Freckles got to school the teacher made a home for him.

She took a large square glass jar about ten inches high.

She put some gravel and some large stones in the bottom of the jar.

Then she poured in some water.

Freckles jumped into his new home.



He liked it very much.

He sat on the stones to warm himself.

He sat in the water to cool himself and drink.

Freckles does not drink water through his mouth as we do.

He absorbs the water which he needs through his skin.

If there were no water in his jar, he would die.

Once a week the teacher fed Freckles a large meal of worms, insects and flies.

That was all he needed to keep healthy.

CHAPTER 8. HOMESICK.

One May day Freckles felt homesick.

Someone had brought some white violets to school.

They made him think of the meadow where he used to live.

Freckles could still smell the sweet perfume of the tiny flower.

He could remember the pretty white blossom.

The center was golden yellow.

The lower petal of the flower had tiny, hair-like lines of purple.

The dark green leaves were shaped just like hearts.

PART II. FRECKLES AND THE FLOWERS.

CHAPTER 1. LADY'S SLIPPER.

One week Freckles studied about flowers.
Monday he found out this about the lady's slipper.
The lady's slipper is one of our most beautiful wild flowers.
It is a member of the orchid family.
We can find it in a moist shady place in the woods.
We must look about the middle of May.
The blossom is a crimson-pink pouch or sac.
It is veined with a deeper pink.
The sepals and petals are purplish-brown and green.
The stem and leaves are light green.

CHAPTER 2. RHODORA.

It was Tuesday.

Freckles wondered what that red-violet blossom was on the teacher's desk.

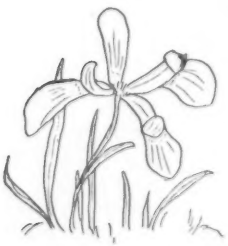
Freckles had never seen such a sparkling, beautiful flower.

He soon found out that it was Rhodora.
The Rhodora is a low-growing shrub about two feet high.
It grows in a swampy, wet place.
It is very scare and hard to find.
The blossom is a vivid pink.

It is three-lobed above and two-lipped below.
There are many long stamens.
They stick out and give the flower its sparkling look.
Freckles decided that it was the prettiest spring shrub.

CHAPTER 3. BLUE FLAG.

Wednesday Freckles learned about an old flower friend.
It was the blue flag that grew in his own meadow.
He knew that some of it grew right near the trickling brook.
Some grew in the swamp at the other side of the meadow.



It grows on long green stalks.
The green leaves are spear shaped.
The blossom is a beautiful pale purple-blue.
It has wax-like lips.
They are daintily colored in yellow and white.

CHAPTER 4. JACK-IN-THE-PULPIT.

Thursday Freckles found out about the Jack-in-the-Pulpit.
It can be found in May and early June.
We must look for it in wet springy ground in the woods.

The Jack-in-the-Pulpit has six gay green leaves that tower above the spathe.

The spathe is the flower.

It is pale green striped with white.

It is shaped like a cup with an overhanging top.

Inside the flower there is a tiny brown club.

The club is Jack himself.

He really looks like a little preacher in a pulpit.

In the fall the Jack-in-the-Pulpit has a cluster of scarlet berries.

The berries are where the spring flower is.

In the berries are the seeds for next year's flowers.

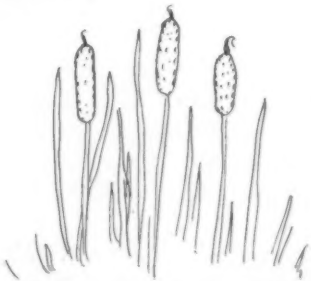
CHAPTER 5. CAT-TAILS.

Friday—Cat-tails.

They were dried and in a jar on a high shelf.

Freckles liked the name.

The cat-tails come in August, but they keep all winter indoors.



They grow in swampy places.

They are from five to six feet in height.

The flowers are in a dense round head at the top of the stem.

They are brown.

The flowers have no petals or sepals.

They are more like bristles.

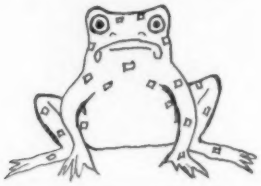
The leaves of the cat-tail are long and narrow.

They look like blades.

They grow near the base of the stem.

Cat-tails grow over all North America.

PART III. FRECKLES AND HIS ANIMAL FRIENDS.



CHAPTER 1. DANNY MEADOW MOUSE.

Freckles studied about Danny Meadow Mouse.

He had seen him many times before he came to school.

He knew that Danny has such long brown fur that it makes him look fat.

His legs and tail are short.

Danny has small eyes, like little black beads.

He digs a short burrow in the ground and at the end of it makes a nice nest of dry grass for his family.

Danny has a large family, for he has a great many babies every year.

He feeds them seeds, clover, bulbs and roots.

All winter and summer he scurries around for food.

Danny is a very busy little creature.

He is always on the watch.

CHAPTER 2. SAMMY SALAMANDER.

Sammy Salamander was one of Freckles' schoolmates.

He lived in a small glass tank over near the window.

This is what Freckles found out about him:

Sammy Salamander is a cunning pet.

He looks like a lizard in shape, and is about six inches long.

His coat is black with yellow spots.

Sammy's home is in wet places under rocks.

There, every night he prowls around for insects, bugs and earthworms.

He thinks they are very good to eat.

Sammy sleeps all winter.

Early in the spring Sammy's babies come.

They are about an eighth of an inch long when they are born.

But they grow up fast and by fall they are as big as their daddy.

Sammy has to be careful that snakes, birds and small boys do not harm him.

CHAPTER 3. SALLY SNAIL.

One night someone placed a tiny jar on the table near Freckles' home.

Freckles knew that some animal was in it.

Finally he got up courage and asked, "Who are you?"

A tiny voice replied:

"I am Sally Snail. I carry my house with me all the time.

It is a little brown spiral-shaped shell.

In the winter I draw myself into it and bar the door.

I stay in until spring.

My two eyes are on inch-long stalks.

I can stick them around a corner and see things before I can be seen.

I eat berries, leaf-bugs and fruit.

I leave my eggs under stones.

When my children are born, they take care of themselves.

When I leave here, you may find me in some stone wall; that is where I stay most of the time."

CHAPTER 4. TIM TURTLE.

Tim Turtle lived in a glass bowl on another table at school.

He wasn't very friendly, but Freckles learned about him from the girls' talk.

Tim is a Cumberland turtle. Out of school he lives in a pond.

Sometimes he suns himself on the rocks.

Sometimes he swims in the water.

All winter long he sleeps, buried in the mud at the bottom of the pond.

For a back Tim has a hard dark-green shell about three inches around.

His tummy is yellow with black spots.

His little head, tail and feet are dark green.

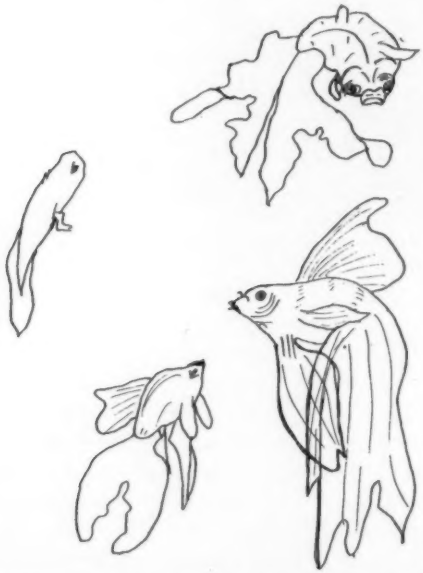
Tim likes water insects and juicy green plants.

His babies come in the spring.

Tim leaves them in the sand on the shore of the pond. They have to take care of themselves.

Tim pulls his head and feet into his shell when he goes to sleep.

It makes a safe covering for him.



A TADPOLE, TWO VEILTAILS AND CALICO TELESCOPE WERE MEMBERS OF OUR AQUARIUM

CHAPTER 5. GOLDFISH.

Freckles liked to watch the goldfish dart to and fro.

The goldfish lived together in a glass aquarium on the center table.

All goldfish first came from China.

There they were green and lived in garden streams.

By cross-breeding the fish became gold and silver in color.

There are many different kinds of goldfish.

They all belong to the carp family.

Goldfish eat ants' eggs and rice wafers.

They do not need very much to eat.

Goldfish sleep at noon and midnight, but they do not close their eyes.

They just remain very still in the water.

They make pretty pets and soon grow to know their master.

CHAPTER 6. MOTHS.

In a big wire cage on the window-sill were some moths.

There were Cecropia moths.

There were Luna moths.

There was one Polyphemus moth.

Once these moths were tiny white eggs on the under side of a leaf.

Finally they hatched.

They were tiny black caterpillars, one quarter of an inch long.

After a while they turned to yellow and later to a bluish-green color.

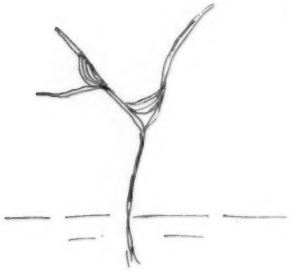
All the while they grew larger, for they ate all the time.

They fed on trees and shrubs.

Then each one spun a little cradle for itself.

It was a dark brown cradle made from a silky substance which each one has in his body.

The moth makes its cradle around itself.
Then when it is done he is safe inside.
He hangs his cradle from a twig on a tree.
He stays there all the winter



In the spring he comes out a beautiful moth.

The moth has no mouth and lives only a few days.

Before death the eggs are laid.

They are to be next year's moths.

Freckles thought they were wonderful.

He decided to find out more about each kind of moth.

PART IV. FRECKLES AND THE BIRDS.

CHAPTER 1. ROBIN REDBREAST.

Freckles knew all about robins, because they are found everywhere.

Robins are among the commonest of our birds.

Freckles liked them because they are always singing good-naturedly.

Robin says: "Cheerily-cheerup, cheerily-cheerup."
The robin has a brown head and black and a red breast.
He is about ten inches long.
He eats earthworms, insects and berries.
The robin makes his nest of mud and grass.
In it are placed four or five tiny green-blue eggs.
When the babies are young, they look like song sparrows.
After a while they look like their father.
During the cold months the robin migrates.
But he is the first bird back in the spring.
The robin is called the "Herald of Spring."

CHAPTER 2. SONG SPARROW.

Freckles next learned about the song sparrow.
Song sparrow is from six to seven inches long.
He has a brown mottled back.
His breast is white spotted with brown.
His home is in the garden, hedges or bushy banks.
He does not like shady woods or forests.

His nest is placed low and is made of grass, bark, and roots.

In the spring four or five bluish-white eggs, generously splashed with brown, are laid.

Soon the babies come, and then the mother and father song sparrows are kept busy feeding them.

They eat seeds, grasshoppers and flies.

Song sparrow migrates during the winter.

He sings a musical song somewhat like a canary's.

Freckles likes him because he is industrious, useful and cheerful.

CHAPTER 3. BLUEBIRD.

Freckles was always happy.

He knew that the bluebird is the symbol of happiness.

Bluebird is about seven inches long.

His head and back are deep blue.

His breast is red, shading to a creamy white near his legs.

He sings a sweet warbling song.

Bluebird builds his nest in trees or birdhouses.

He lines it with grasses.

The six eggs are pale blue.

When babies come, Bluebird feeds them insects, seeds and cankerworms.

Sometimes, he himself, eats berries and small fruits.

The bluebird migrates but does not go very far away.

He lives near people but is hard to tame.

CHAPTER 4. GOLDFINCH.

The goldfinch caught Freckles' eye.

He is such a beautiful golden color.

His wings and the top of his head are black.

The goldfinch is small—about four and a half inches long.

He eats weeds, worms, caterpillars, grubs and sunflower seeds.

The gold finch makes his nest in the late summer.

It is of bark and moss lined with thistledown.

The four eggs are pale blue.
The goldfinch stays in the north all winter.
Then his gay dress changes to brown.
He looks like his mate in the winter.
The goldfinch sings a sweet song.
He calls 'per-chic-o-ree" many times.
Tiny though he is, he is of much help to the farmer.

CHAPTER 5. RED-WINGED BLACKBIRD.

The next bird that Freckles studied was the red-winged blackbird.
His body and wings are black.
On his shoulders there is a patch of red with a yellow border.
That is how he gets his name.
He is about nine inches long.
The red-winged blackbird hangs his nest of rushes from bushes near swamps or marshes.
There are from three to five whitish eggs.
The eggs are marked around the large end with black in a "V" shape.
The red-winged blackbird eats rice, seeds, and insects.
He goes south in the winter but returns north early in the spring.
The father comes first and looks for a nest site.
Then the mother bird comes.
Red-winged blackbird says, "Conk-err-ee."

CHAPTER 6. BOBOLINK.

Bobolink was next.
Freckles liked to say his name over and over again.
Bobolink likes to also; he sings "Bob-o-link-link-link," all the time.
He is about eight inches long.
His head, breast and wings are black.
He has a yellow patch on the back of his neck.
His shoulders and back are white.
Bobolink looks as though he had his shirt on backwards.
He lives in a meadow and builds his nest in a hollow on the ground.
The four eggs are laid in the spring.
They are white spotted with brown.
Bobolink eats seeds and insects.

He goes south in the winter.

Then his yellow, black and white feathers change to dark brown and white.

He then looks like his mate.

CHAPTER 7. FRECKLES GOES HOME.

Freckles had been at school a long while.

It was time for him to go back to his home near the trickling brook.

He was sorry to leave all his friends at normal school.

But when he reached home he was very happy to see his mother, father and cousins once again.

Then all he had to do was:

Dive in the morning, swim in the afternoon, and sing all evening.

A Note to the Teacher

The animals in this book are those which any teacher, with a little effort, may keep in her classroom. The children's interest in and appreciation of live pets will increase a hundredfold if they are in the room where they can care for them and study them. The social, aesthetic and educational values of such classroom animals cannot be too greatly stressed.

I chose the particular flowers that I described because most of them are associated with the meadow and swamp—Freckles' home. The names also, I thought, were most fascinating—Cat-tails, Blue Flag, Jack-in-the-Pulpit.

The birds described are our most familiar feathered friends. Beginning the study of birds, we should first take up those which we see about us and of which the children have some knowledge on which to build.

The teacher could use this material in Grades 3 or 4:

1. As an introduction to the study of birds, flowers and animals.
2. As a motivation to all nature lessons.
3. As an outline and guide in teaching the selected subjects and any subject in nature study.

For effective teaching it is suggested that mounted birds be used (in the absence of real ones in the neighborhood), that the children bring in flower specimens, if possible, and that animals be kept in classrooms.

SAMPLE QUESTIONS. The teacher should ask questions on every story and chapter. For example, on the first part:

1. What does Freckles look like?

2. Where is his home?
3. Describe how to make a home for him in the classroom.
4. What does he eat?
5. What are some of the things he does?
6. Does he drink water?

Questions should be asked that would call for the habitat and characteristics of the wild flowers; that would necessitate comparison of bird habits, type of eggs, home and nests, and so forth. Factual, thought and organization questions should be asked.

CORRELATIONS. The study could be correlated with:

1. Reading—child reads book, poems, etc.
2. Spelling—child spells troublesome words.
3. Language—*Oral*—child tells of what part or chapter he likes best and why. Tells part to another child who was absent during the reading.
   Written—child writes stories and descriptions in his own words.
4. Picture Study—child imagines new situations which could arise from the pictures.
5. Singing—child sings those songs in the music book which have to do with flowers, animals and birds.
6. Health—child gets out of doors to watch for birds, and seek out new flowers.
7. Arithmetic—child measures and draws comparisons concerning birds, nests and eggs.

A fourth or fifth grade child could read "Freckles Frog" for himself in his nature work. It will give excellent silent reading opportunities thus used.

DIFFICULT WORD LIST

absorb	lobed	sepals
bask	Luna	stamen
burrow	migrate	spathe
cluster	mottled	spiral
Cecropia	petal	symbol
dense	Polyphemus	

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Birds of Massachusetts and Other N. E. States—Forbush.
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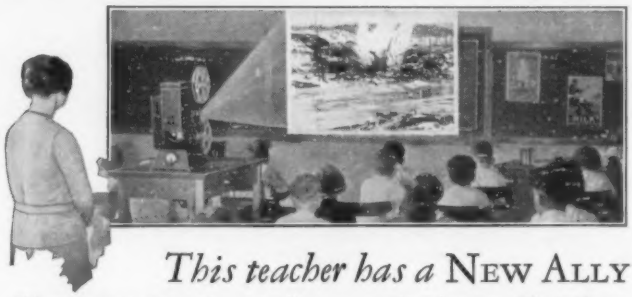
In the preparation of "Freckles Frog" I am greatly indebted to the authors listed above. I thank them one and all.



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The Psychology of Learning Applied to Health Education Through Biology—1929—Anita D. Laton—103 pages—$1.50—Bureau of Publications, Teachers College, Columbia University.

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General Science—1929—Richard W. Sharpe—240 pages—98 illustrations—paper covers—$.68—Oxford Book Co.

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Drill Exercises in Chemistry—1929—J. Ellis Stannard—149 pages—Oxford Book Co.

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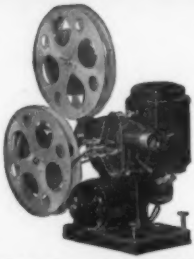

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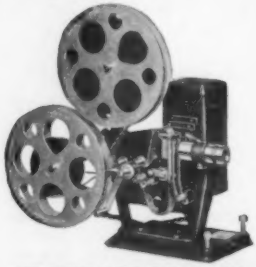

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An Important Merger in the Amateur Motion Picture Field—Q. R. S.-DeVry Corporation

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Magazine List

American City. 443 Fourth Ave., New York City. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

Commercial America. Philadelphia Commercial Museum, Philadelphia, Pa. $2.00 a year. Ill. Commercial production. New inventions. Will interest commercial geography and science teachers.

Current Science. 40 South 3rd St., Columbus, Ohio. Weekly during school year. $1.00 per year. This is a student's news sheet, giving interesting science news of the world; it will add life to the work of the general science class.

The Educational Screen. 5 South Wabash Ave., Chicago. 10 months. 25c a copy, $2.00 a year; with "1000 and One Films," $2.25 a year. Discusses the use of motion pictures, slides, and other visual aids in our schools; gives brief descriptions of educational films, and lists of theatrical films which are suitable for children. The journal is entirely educational, having no commercial affiliations.

The Home Economist. 468 Fourth Ave., New York City. Monthly. 10c a copy, $1 a year. Gives practical discussions of everyday classroom problems, lesson outlines and plans.

The American Home. Garden City, N. Y. Monthly. $1.00 a year. Helpful suggestions to the amateur gardener, home maker, teacher and pupil.

Science Education. Salem, Mass, Quarterly. 40c a copy. $1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 North Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

Journal of Chemical Education. 85 Beaver Street, New York, N. Y. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 617 Mills Bldg., 700 17th Street N. W., Washington, D. C. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., New York. Weekly. 10c a copy, $4.00 a year. Has a department, "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high-grade pictures. Articles are of interest to general readers, pupils and teachers, as well as to geographers.

The American Journal of Public Health and The Nation's Health. 370 Seventh Ave., N. Y. C. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpful to the science and hygiene teacher.

Photo-Era Magazine. Wolfeboro, New Hampshire. Monthly. 25c a copy, $2.50 a year. This magazine is for the beginner, the advanced amateur, and the professional photographer. It has much for the science department of universities, schools and summer camps, and will help instructors and pupils to make better photographs.

Popular Mechanics Magazine. 200 E. Ontario St., Chicago. Monthly, 25c a copy, $2.50 a year. A popular scientific magazine, covering in well illustrated articles developments of general interest in all branches of science and mechanics, in a form usable in classroom work.

Popular Science Monthly. 225 West 39th Street, New York City. Monthly. $2.50 a year, 25c a copy. A review in text and pictures of the news of science and invention, presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

Radio. Pacific Building, San Francisco, California. Monthly, 25c a copy, $2.50 a year. Devoted to the technique of radio. Of special interest to science teachers. It gives an explanation of why and how radio equipment works.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Science Classroom. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secondary science teachers.

Scientific American. 24 West 40th St., New York. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated. Particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place, New York City. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and, in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles, as a rule, are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

Science News-Letter. Science Service, 1115 Connecticut Ave., Washington, D. C. Weekly. 10c a copy, $5.00 a year. Gives a valuable current summary of the progress of science, in a form usable in science classes.

Transactions of the Illuminating Engineering Society. 29 West 39th Street, New York. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.